The Effect of Winter Pipeline Construction on the Fishes and Fish Habitat of Hodgson Creek, NWT

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ABSTRACT

McKinnon, G.A., and F.N. Hnytka. 1988. The effect of winter pipeline construction on the fishes and fish habitat of Hodgson Creek, NWT. Can. Tech. Rep. Fish. Aquat. Sci. 1598: iv + 44 p.

During the winter of 1984/85 a small (30.5 cm) diameter underground pipeline was built across Hodgson Creek, NWT as part of a line from Norman Wells, NWT to Zama, Alberta. The effects of construction and operation of this ambient temperature oil pipeline on fish and fish habitat in Hodgson Creek were studied from 1983 to 1987.

There was no detectable effect of pipeline construction or operation on stream discharge, velocity, temperature, dissolved oxygen or water chemistry.

Winter bridge construction in December, 1984 increased the instantaneous total suspended sediment (TSS) level from 2 $mg \cdot L^{-1}$ to 26 $mg \cdot L^{-1}$. Seven hours later the TSS level equalled the pre-construction value.

Pipeline trenching increased the TSS level from 1 $mg \cdot L^{-1}$ to 3524 $mg \cdot L^{-1}$. Other construction activities including pipe-laying and backfilling produced lesser increases in TSS than did trenching. High TSS levels attenuated quickly both over time and distance; four days after all in-stream construction ceased the TSS values downstream of the construction site equalled pre-construction values.

Twenty-four hour average deposition in sediment collectors placed 50 m downstream of the pipeline increased from <1 $mg \cdot hr^{-1}$ to 140 $mg \cdot hr^{-1}$ as a result of construction activity.

The headwaters of Hodgson Creek provide winter habitat for Arctic grayling (Thymallus arcticus), slimy sculpin (Cottus cognatus), and a small number of lake chub (Couesius plumbeus), longnose sucker (Catostomus catostomus), burbot (Lota lota) and northern pike (Esox lucius). Winter pipeline construction across the lower portion of this overwintering habitat appears to have had no effect on the fish which reside there during winter.

It is postulated that the Arctic grayling which overwinter in the headwaters of Hodgson do not comprise a resident population because no mature Arctic grayling were captured there during winter.

Keywords: fish biology; fish habitat; pipeline; sediment deposition; suspended sediment; winter.

RÉSUMÉ

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Dans le cadre de la construction du pipeline de Norman Wells (T.N.-O.) à Zama (Alberta), un pipe-line enterré de 30,5 cm de diamètre a été passé transversalement dans le ruisseau Hodgson, dans les Territoires du Nord-Ouest, au cours de l'hiver de 1984-1985. Les effets qu'ont entraîné la construction et l'exploitation de cet oléoduc à température ambiante sur le poisson et l'habitat du poisson ont été étudiés de 1983 à 1987.

Ni la construction du pipe-line ni son exploitation n'a eu d'effet mesurable sur le débit, la vitesse d'écoulement, la température, le niveau d'oxygène dissous ou la composition chimique de l'eau dans le ruisseau.

La construction d'un pont en décembre 1984 a fait passer le niveau instantané des sédiments en suspension de 2 $mg \cdot L^{-1}$ à 26 $mg \cdot L^{-1}$. Sept (7) heures plus tard, le niveau était cependant retombé à ce qu'il était avant la construction.

Le creusement de la tranchée pour le pipeline a fait augmenter le niveau des sédiments en suspension de 1 $mg \cdot L^{-1}$ à 3 524 $mg \cdot L^{-1}$; toutefois, les autres travaux de construction, notamment la mise en place du tube de la conduite et le comblement de la tranchée, ont fait augmenter le niveau des sédiments en suspension dans une moindre mesure. Les niveaux élevés se sont rapidement abaissés avec le temps et la distance; ainsi, quatre (4) jours après la fin de la construction dans le ruisseau, les niveaux des sédiments en suspension en aval du point de construction étaient à nouveau comparables à ce qu'ils étaient avant la construction.

La moyenne des dépôts sur une période de vingt-quatre (24) heures dans des collecteurs de sédiments placés à 50 m en aval du pipe-line ont augmentés de <1 $mg \cdot h^{-1}$ à 140 $mg \cdot h^{-1}$ comme suite aux travaux de construction.

Le cours supérieur du ruisseau Hodgson sert d'habitat hivernal à l'ombre arctique (Tymallus arctivus), au chabot visqueux (Cottus cognatus) ainsi qu'à un petit nombre de menés de lac (Couesius plumbeus), de meuniers rouges (Catostomus catostomus), de lottes (Lota lota) et de grands brochets (Esox lucius). La construction du pipe-line au cours de l'hiver dans la partie inférieure de cet habitat d'hivernement ne semble avoir eu aucun effet négatif sur les poissons qui y passent l'hiver.

On présume que l'ombre arctique qui se réfugie pour l'hiver dans le cours supérieur du ruisseau Hodgson ne comporte pas de population résidente, car on n'y a pris aucun ombre mature au cours de l'hiver.

Mots-clés: biologie du poisson; habitat du poisson; pipe-line; dépôt de sédiment; sédiments en suspension; hiver.

INTRODUCTION

Imperial Oil Ltd. first discovered an oil field at Norman Wells, 90 miles south of the Arctic Circle, in 1918. It was not until 1932, however, that the demand for oil products in the western Northwest Territories became large enough to permit the producing and refining of crude oil on a regular basis at Norman Wells. In that year a small refinery was built on site.

In 1980 Esso Resources Canada Ltd. indicated its desire to increase oil production from the Norman Wells oilfield by accessing that part of the reservoir which lies under the Mackenzie River. This was to be accomplished by drilling 190 new wells on the mainland, on Bear and Goose Islands, and on six small artificial islands to be built in the Mackenzie River. As a related proposal, Interprovincial Pipeline Ltd. indicated its intention to build and operate a small (30.5 cm) diameter underground pipeline to transport the additional crude oil production from Norman Wells to Alberta. Both proposals were granted approval by the Minister of Indian and Northern Affairs Canada in August 1981 contingent upon a two-year delay to allow the indigenous people and various territorial and federal government departments to make preparations for the anticipated activities. Mainline pipeline construction commenced in the fall of 1983 and was completed in the spring of 1985.

Proposals to construct a pipeline along the Mackenzie Valley for transportation of the hydrocarbons to southern markets are not new. In the early 1970's both Canadian Arctic Gas Pipeline Ltd. and Foothills Pipe Lines Ltd. proposed to construct a large diameter chilled gas pipeline along the Mackenzie Valley. These plans were subject to considerable government and public review (e.g. Government of Canada Environmental - Social Program, Northern Pipelines, Task Force on Northern Oil Development; The Mackenzie Valley Pipeline Inquiry, etc.). The concept of a transportation "corridor" was central to deliberations of the Mackenzie Valley Pipeline Inquiry (Berger, 1977). The influence of the first trunk pipeline in shaping the transportation corridor system and in moulding the environmental and social future of the region was considered by many to be enormous. It was believed similarly that such a corridor could eventually include roads, a railroad, hydroelectric transmission lines and telecommunication facilities. As a result of the Inquiry, Berger (1977) concluded that construction of a pipeline along the Mackenzie Valley was feasible from an environmental point of view, but recommended that it be postponed for ten years to allow for settlement of native land claims.

The Norman Wells Pipeline tests the feasibility and environmental acceptability of building a pipeline in the Mackenzie Valley. Because of the nature of this pipeline (i.e. small diameter, ambient temperature, buried) it was not expected to have many of the serious environmental implications of the earlier pipeline proposals.

Under provisions of the Fisheries Act, the Department of Fisheries and Oceans has a responsibility to ensure that no work or undertaking results in the harmful alteration, disruption or destruction of fish habitat. The current study deals only with the pipeline portion of the Norman Wells Project. The effects, on overwintering fish populations and habitat, of winter construction of the small diameter pipeline are of particular interest. Actual construction of the pipeline tests the validity of impact predictions and the effectiveness of mitigative measures identified through review (e.g. EARP) and regulatory proceedings. A long term objective is the development of environmental guidelines for future projects similar in nature.

This report deals with the effects of pipeline construction on the fish and fish habitat of Hodgson Creek. The effects on the benthic macroinvertebrate community structure in Hodgson Creek are considered in Young, 1986.

DESCRIPTION OF STUDY AREA

The study was conducted on Hodgson Creek, a second order tributary of the Mackenzie River (Fig. 1). The study area was located approximately 20 km northeast of Wrigley, NWT (63°21'N, 123°30'W). Hodgson Creek originates in the McConnell Range of the Franklin Mountains on the east side of the Mackenzie River. These thrust masses of Silurian-Ordovician dolomites, limestones and shales have a maximum altitude of 1700 m a.s.l. and are covered for the most part by a shallow veneer of glacial drift deposits. Inactive thrust faults tending northeastward at the base of the Range are responsible for the many groundwater discharge sites in the area, one of which provides basal flow for Hodgson Creek.

The Mackenzie River Valley in this region is rather narrow, being confined between the Mackenzie and Franklin Mountains. The valley itself is dominated largely by silty and clay-rich soils of lacustrine and alluvial origin. The region around Wrigley can be considered transitional with respect to ground ice conditions and dynamics. To the south are large areas of alluvial and a variety of organic terrain; areas further north contain more typical Arctic terrain with more abundant ice-cored peat polygons.

The climate of the area is semi-arid and subarctic to cold temperate in type. The mean annual precipitation in Wrigley is close to 32 cm, 20 cm of which fall as rain in the summer months. Mean annual temperature is approximately -5°C.

Hodgson Creek is confined within a cobble floodplain. The channel and floodplain consist of gravel and cobbles with a median diameter of 60 mm and occasional boulders to 500 mm in diameter. After egress from mountainous terrain the stream channel follows an irregular meander path across this floodplain and has been historically active laterally. Braided flow is common.

Hodgson Creek has a total length of approximately 33 km and a drainage area of 165 km^2. The average gradient of the stream in the study area is 1.04%. At base flow the stream has a typical riffle-pool sequence. Base flow discharge is approximately 0.12 $m^3 \cdot sec^{-1}$. Peak discharge usually occurs during spring snowmelt (April and May) and then gradually declines over the ice-free season (May to October). However, discharge is extremely variable because severe spates occur following rainfall events in the headwaters.

Soils in the study area are in a glaciolacustrine plain consisting of silt and clay deposits. Adjacent to the creek are extensive alluvial fans composed of sand and gravel. In the region of the pipeline crossing, stream banks are generally low (less than 5 m). However 1 km upstream and beyond banks can be high and without vegetation.

The study area is located in the Boreal forest region; dominant vegetation consists mainly of white spruce (Picea glauca), black spruce (Picea mariana), jackpine (Pinus banksiana), white birch (Betula papyrifera) and trembling aspen (Populus tremuloides).

METHODS AND MATERIALS

The Norman Wells pipeline monitoring study was begun in March 1983 when we conducted a field survey to select streams suited to year-round study. On the basis of information collected and other published data, Hodgson Creek was finally chosen for further study. The two main features which made Hodgson Creek conducive to a monitoring study were (1) an overwintering group of fish at and near the proposed pipeline alignment and (2) a location in construction spread 2 indicating planned construction in 1985 rather than 1984.

Data was collected on a wide range of physical and biological parameters so that any effects due to pipeline construction or operation could be determined. The study was designed to continue until 1987 in order to assess both short and long term effects. Sampling was conducted during winter, summer and fall (Table 1).

Main sampling locations (Fig. 2) were established 475 m and 625 m (Stations U1 and U2 respectively) upstream of the pipeline centreline to serve as control stations. Downstream of the pipeline Stations D1, D2 and D3 were established 50 m, 275 m and 400 m respectively from the pipeline centreline to study the effects of pipeline construction on fish habitat. Other sampling stations were utilized only occasionally.

Station U5 is located above the confluence of Hodgson Creek with the spring source (Station S2) which provides winter flow. Station U4 is downstream of the confluence of these two flow sources. Station U3 is located at a pool area which provides overwintering habitat for fish and provides a suitable site for their capture. Station B was a temporary site located between the winter road and the pipeline crossing of Hodgson Creek and was used to quantify effects from winter road construction in December, 1984. Station D4 was used only occasionally because of channel shifting in the area and Station D5 was utilized exclusively for placement of a hoop net during pipeline construction.

PHYSICAL PARAMETERS

Stream velocity and discharge

Discharge measurements were taken at various locations in order to determine flow rates and any differences in rates between stations were noted. Water velocity determinations were made with a Marsh McBirney model 201 portable electromagnetic meter or a Price Gurley pygmy meter. Velocity readings were integrated over a 40 second interval for the Marsh McBirney meter and a minimum of 30 seconds was used for the Price Gurley meter. Measurements were made at 0.6 of total depth and discharges were calculated using the midsection method (USDI 1967).

Stream morphology

A Sokkisha model B2A automatic engineers level was used to determine stream gradient and bank height. All elevations were tied into one fixed benchmark near Station S2 which was arbitrarily assigned an elevation of 100 000 m.

Stream physical characteristics were determined from interpretation of air photographs supplied by the Canada Map Office as well as photographs taken from a helicopter. All observations were ground truthed.

Sediment deposition

Sediment collection traps consisted of 170 mm lengths of 38 mm diameter PVC piping sealed at one end and inserted into an outer sleeve of 51 mm piping which was embedded vertically into the stream bottom. Aspect ratio of the collection tubes was approximately 5 to 1 in order to minimize resuspension influences and to facilitate installation and handling. Three of these samplers were installed across the stream at each of the designated stations.

Samplers were collected periodically during the winter of 1985. Contents were placed in plastic bags and allowed to freeze solid for transport and storage. Analysis of these samples consisted of decanting excess water then freeze-drying the remainder. Individual samples were then weighed for total sediment, combusted at 380°C for 16 hours for organic content determination and finally seived. For this, a U.S. Standard #230 seive was used in order to separate the silt fraction (particle size $\leq$0.062 mm) from the courser sands and gravel.

Water quality

Total suspended solids: One litre water samples were collected by hand filling bottles at the surface on a periodic basis from selected stations. These were either filtered in the

field with the filters subsequently returned to laboratory facilities in Winnipeg for weighing, or in some cases returned whole to Winnipeg for both filtering and weighing. In both cases aliquots of each sample were filtered through preweighed 0.45 M Whatman GFC filters, dessicated and reweighed. Suspended solids concentrations were then calculated ($mg.L^{-1}$). Methods were according to Stainton et al. (1974).

Percent organic content was calculated by ashing the samples at 380°C for 16 hours then reweighing.

Temperature: Water temperatures were determined to 0.5°C using a hand-held pocket thermometer. Continuous temperature data was periodically provided through the use of Ryan (Model J) thermographs.

Dissolved oxygen: Dissolved oxygen determinations were carried out by means of the titrimetric method. Samples were collected on a regular basis from each station and analyzed immediately.

Nutrient elements, cations, anions and miscellaneous measurements: One litre water samples were collected by hand filling bottles at the surface from designated stations during each of the sample periods and returned to laboratory facilities in Winnipeg for analysis of the following parameters: suspended carbon, suspended nitrogen, soluble reactive phosphate, suspended phosphate, total dissolved phosphate, dissolved inorganic carbon, dissolved organic carbon, soluble reactive silicon, chloride, sulphate, total suspended iron, conductivity, sodium, potassium, calcium, magnesium, iron, manganese, pH, alkalinity, organic acids, and percent organic matter. Methods were as outlined in Stainton et al. (1974).

BIOLOGICAL PARAMETERS

Fish collection

Fish collection was directed at determining species composition, habitat utilization and growth characteristics of fish. Techniques employed did not allow catch per unit effort determination. Variable flow conditions, ice cover and water quality made it necessary to utilize a number of fish collection techniques over the course of the program.

Gillnets: Multifilament gillnets of variable length and of 25 mm to 50 mm stretched mesh were used primarily during open water season under low flow conditions and were set in pools or suitable glide areas. Efforts to employ gillnets in the winter proved to be impractical.

Electroshocker: A Smith Root model 11-A or a Coffelt model BP4 electroshocker was used year round. These provided useful information at times but their use was limited during high water conditions and they proved ineffective on many occasions when water conductivity exceeded the operating ranges of the units.

Seine nets: Reach seine nets of 3.7 m or 6.1 m length and 1.2 m depth with 6 mm mesh were used under low flow conditions in some locations.

Angling: A variety of spin casting tackle and lures was used to angle for fish primarily during summer and fall sampling periods. Angling was effective except during extreme flood events.

Dipnets: Fine mesh dipnets secured to a 1 m long handle were periodically used in confined areas to capture small fish.

Hoop net: A single hoop net constructed of 6 mm mesh was set in a location downstream of the pipeline alignment during actual pipeline construction. The trap was positioned so as to capture only downstream migrants and the wings were extended from the hoop to each stream bank so as to completely block the stream.

Drift nets: Incidental catches of fish came from invertebrate drift nets.

Fish treatment and analysis

Samples of fish captured were retained for detailed analysis. Some fish were analyzed in the field, others were preserved in 70% ethanol or 10% formalin and returned to Winnipeg for detailed analysis.

Fish identification

The taxonomic keys provided by McPhail and Lindsey (1970) and Scott and Crossman (1973) were used for the identification of all species.

Sampling

Information collected from sampled fish included fork length (to 1 mm), weight (to 0.1 g) and state of sexual maturity. Otoliths, scales, and or fin rays were removed for aging purposes and stomachs were removed and preserved in 70% ethanol for later analysis of contents.

Aging

Otoliths: Otoliths were removed from all fish and stored in glycerin-filled vials. Prior to examination otoliths were transferred to a benzyl benzoate/methyl salicylate clearing solution. Reading was performed under reflected light using a stereo dissection microscope.

Scales: Scales were removed from the left side of the fish body near the base of the dorsal fin then placed in manilla envelopes and allowed to dry. Annuli were interpreted by reading scales mounted between opposing glass slides using a Leitz trichinoscope. All ages are reported in terms of number of winters survived.

Both otoliths and scales were removed from Arctic grayling for aging purposes. Subsequent comparative reading of these structures gave reasonably consistent results. However, the

scales were by far the easiest of the two structures to read and we are more confident of the accuracy of results obtained. Therefore only scale ages are reported herein.

RESULTS AND DISCUSSION

STREAM VELOCITY AND DISCHARGE

Velocity and cross-sectional area measurements were taken and subsequently discharge was calculated at a number of locations on Hodgson Creek over the course of study. This was done to determine whether pipeline construction or operation affected Hodgson Creek discharge. A decrease in discharge could adversely impact downstream biological resources especially in winter.

The data (Table 2) are not representative of all flow conditions in Hodgson Creek but are biased towards low flow conditions because of our measuring techniques which required wading across the stream. As well, winter ice conditions near the pipeline crossing area prevented us from obtaining discharge measurements on many occasions.

Basal flow from the spring source at Station S2 is approximately 0.12 $m^3 \cdot sec^{-1}$ and remains relatively constant throughout the year. Peak discharge usually occurs during spring snowmelt (April and May) and flow gradually declines over the ice-free season (May to October). Our data show a maximum discharge of 4.67 $m^3 \cdot sec^{-1}$ (Station U5) on July 3, 1984 but this is not indicative of the high flows which occur as a result of snowmelt or heavy rainfall. A severe rainfall event which occurred in June 1986 produced very high discharge values in Hodgson Creek and led to changes in the channel configuration near the pipeline alignment. Unfortunately, we were not on site at the time of this flood and are not able to provide any estimate of its magnitude.

Because of ice conditions on Hodgson Creek during the winter of 1985 discharge was not calculated for stations downstream of the pipeline alignment during and subsequent to construction activities. However, there appeared to be no diversion of flow at the crossing site and no ice buildup was noted as a result of the construction activities.

Post-construction data show no detectable effect of pipeline operation on flow and there has been no visible indication of ice-bulb formation around the pipeline. On January 30, 1986, discharge at the spring source S2 and downstream of the pipeline at Station D1 was identical.

STREAM MORPHOLOGY

A spring (Station S2) at the base of the McConnell Range provides year round flow for Hodgson Creek. Upstream of this flow source the Hodgson Creek floodplain is confined within steep banks. Downstream, banks are low and the stream channel follows an irregular path within a broad cobble floodplain. The Norman Wells pipeline crosses Hodgson Creek at a point approximately 1.6 km downstream from the spring source. Analysis of aerial photographs indicates that the Hodgson Creek floodplain in this area has been subject to considerable lateral movement historically.

Station U1 on Hodgson Creek is at the approximate downstream limit of open-water in mid-winter. Depending on daily weather conditions in winter, open water may extend downstream approximately to the pipeline right-of-way. From this point downstream in our study area, flow is generally under ice. Extensive aufeis fields begin to form near Station D3 and we believe that eventually under-ice flow is cut off completely.

Virtually no change in channel configuration occurred within the study area from July 1984 to July 1985 (Fig. 3, 4 and 5). However, as a result of a severe flood event in 1986, Hodgson Creek shifted to the north side of its floodplain in the vicinity of the pipeline right-of-way (Fig. 6). This stream channel eroded the north bank of the floodplain and began to flow very near to or outside of the area of pipe protected by deep burial and saddle weights. As well a stream cut-off channel began to form to the south of the main channel resulting in flow across and down unprotected stretches of the pipeline alignment.

Berger (1977) indicates that a pipeline designer has two options when crossing channels that migrate at significant rates across a flood plain: he can either locate the sag bends outside the present and potential future channel zone, burying the pipeline deeply all across the channel zone, or he can squeeze the channel zone with river training works and build only a short river crossing. From an environmental point of view, the first alternative is usually preferable because it reduces the risk of having to undertake major repair or maintenance work.

Neither of the alternatives as outlined by Berger (1977) was implemented during construction of the Hodgson Creek pipeline crossing. Because of channel shifting in 1986, Interprovincial Pipeline Ltd. decided to train the stream back into its former channel at the pipeline crossing. This included moving the stream channel southward to approximately mid-way between sag bends, excavating the stream channel approximately 1 m over the pipeline right-of-way and constructing a training berm on the north bank. All of the construction was undertaken in February, 1987.

SEDIMENT DEPOSITION

Sediment deposition, even in moderate amounts has been shown to reduce the survival of fish eggs and alevins (Cooper 1965; Cordone and Kelly 1961). Sediment deposits decrease flow through the gravel, thereby limiting the supply of oxygen to the eggs. There is no evidence of fall spawning in Hodgson Creek near the pipeline crossing and therefore the possibility of there

being eggs in stream gravels in the area during winter is remote. Deposition rates are presented here, therefore, for comparative purposes only.

Instream construction activities on February 16 and 17, 1985 led to a dramatic but short-term rise in levels of sediment deposition at proximal downstream stations. The results from three arrays of collection tubes placed in Hodgson Creek are presented in Fig. 7. The deposition rate at Station D1 increased from a pre-construction level of <1 mg·hr^{-1} on February 13 to a level of 41 mg·hr^{-1} and 18 mg·hr^{-1} at Station D1 and D2 respectively on February 17 while instream work was ongoing. On February 18 these levels were 140 mg·hr^{-1} for Station D1 and 22 mg·hr^{-1} for Station D2. The percent organic content decreased during times of high deposition indicating that most added material due to construction was inorganic in nature.

Another major impact of sediment deposition is the possible alteration of the stream bed, i.e., the substrate that benthic organisms and fish depend on for feeding, growth and reproduction. Increased siltation in a river or lake generally results in decreased abundance and diversity of aquatic organisms (Brunskill et al. 1973). Barton (1977) showed that rechannelization after completion of a highway culvert in southern Ontario increased sediment deposition ten-fold to 0.61 g dry wt/cm^2 day. A decreased proportion of organic matter in the sediment indicated that it likely originated from the construction site. Shapely and Bishop (1965) added sediment to a small southeastern Alaskan stream. They found that the amount of sediment settling to the stream bottom decreased exponentially with distance downstream. In Caribou Bar Creek and the Rengleng River, NWT, sands and silt appeared to accumulate near the point of entry of added sediment to the river channel, but finer silts and clays were transported a short distance (23 km) to downstream pool areas where they were sedimented in waters of lower velocity (Rosenberg and Snow 1975). Rosenberg and Wiens (1975) found that 85% of a silty sediment added to experimental channels of the Harris River was deposited on the stream substrate within the first 7.5 m and 90% within 15 m of the site of sediment addition.

The high deposition rates found on February 18 in Hodgson Creek were not sustained; by February 19 the rate at both downstream stations had fallen to 1-2 mg·hr^{-1}. No material deposited as a result of construction during the winter of 1985 was evident after the spring freshet of 1985 and appears to have been flushed away from the area during that freshet.

WATER QUALITY

Total Suspended solids

Two instream construction activities affected suspended sediment levels in Hodgson Creek during the winter of 1984/1985. These were (1) construction of a temporary winter bridge across the stream approximately 200 m above the pipeline on December 6, 1984 and (2) pipeline trenching, laying and back-filling on February 16 and 17, 1985.

Winter bridge construction on Hodgson Creek consisted of spanning the stream with logs, constructing approaches of ice and snow, then covering the bridge with snow and water to provide a stable ice platform. Sediment addition associated with these activities occurred as a result of (1) heavy machinery fording and (2) covering the bridge with sediment laden snow which was inadvertently pushed into the stream. These activities boosted total suspended solids (TSS) from a pre-construction value of less than 2 mg·L^{-1} to a recorded high of 26 mg·L^{-1} at Station B on December 6 (Table 3). By approximately 7 hours after the peak was reached the TSS construction at this station had decreased to approximately the pre-construction value.

McCart and de Graaf (1974), indicate that winter road stream crossings can have damaging effects on stream habitats. These include sedimentation of the stream substrate by materials incorporated in the bridge, blockage of fish migrations and scouring of the stream bottom as flood waters pass under the bridge at high velocity. Porter et al. (1974) report on a study of the Martin River near Fort Simpson, Northwest Territories during construction of the Mackenzie Highway. Their study shows slightly elevated suspended sediment concentrations below a right of way slash (completed by mid-September, 1972), a winter road (in place by early November, 1972) and a temporary bridge constructed by the end of March, 1973).

Instream trenching across Hodgson Creek began shortly before 10:00 hr on February 16, 1985. Total suspended solids concentrations before trenching were generally 1 mg·L^{-1} at both upstream and downstream stations. At 10:00 hr a TSS concentration of 3524 mg·L^{-1} was recorded at Station D1. This is the highest concentration we found in our study. Similarly, high values were also found at stations further downstream, however our values of TSS do not show a direct attenuation spatially due to the pulsed nature of sediment loading. It was not possible to follow a particular pulse of sediment laden water as it progressed downstream, therefore, values from one station to the next are not directly comparable.

Total suspended solids concentrations fluctuated widely on February 16 because of the intermittent nature of in-stream construction. Maximum levels occurred at the outset of pipeline trenching and all subsequent in-stream construction produced lesser peaks in TSS concentration. Construction activity ceased for the day at approximately 2000 hr on February 16; by midnight the TSS value at Station D1 had fallen to 41 mg·L^{-1} with similar values recorded for all other downstream stations. The TSS value at Station D1 was 24 mg·L^{-1} at 0800 on February 17.

Most activities on February 17 including pipelaying caused little disturbance to the stream bed and as a result TSS values remained relatively low until 1600 hr. The 1600 hr values show an increase in TSS due to sediment addition from trench back-filling. The peak TSS

loading was apparently missed at Stations D1 and D2 at this time, but is probably more accurately reflected at Stations D3 and D4.

As on February 16, TSS values at downstream stations decreased rapidly once in-stream construction activity ceased. By midnight, values in the order of 10 $mg \cdot L^{-1}$ were present at all stations. After that, values were generally less than 10 mg/L^{-1} at all stations and on February 21 the value at Station D1 fell to 1 $mg \cdot L^{-1}$, thereby equalling TSS values upstream of the construction site. Values at Stations D2, D3, D4 and D5 were still slightly higher on that date probably because the stream was flushing material which had previously settled downstream of the construction site.

It is evident from our data that winter construction of the pipeline caused increased siltation of Hodgson Creek by means of direct disruption of the stream substrate, not through increased run-off from adjacent land areas. There was very little erosion of streambank material because of its frozen state and addition of sediment to the stream essentially ceased once in-stream work was completed. Sediment added to flowing water as a result of construction activities was comprised of mainly inorganic material. This is indicated by the sharp decline in percent organic composition of suspended sediment samples at times when TSS values increased.

During construction of a highway culvert in Southern Ontario, Barton (1977) observed that suspended solids increased to as high as 1390 $mg \cdot L^{-1}$, but later returned to preconstruction levels of <5 $mg \cdot L^{-1}$. As well, Galt Creek, a small brook trout (Salvelinus fontinalis) stream was monitored by Mathers (1978) before, during and after construction of a four-lane divided highway in Ontario. He noted that during construction, suspended sediment concentrations below the construction site rose to 5,945 $mg \cdot L^{-1}$ compared to a maximum of 31 $mg \cdot L^{-1}$ before construction. In August, 1972, a natural mudslide occurred on Caribou Bay Creek, NWT. Suspended sediment values were 3.82 $mg \cdot L^{-1}$ above and 10.6 $mg \cdot L^{-1}$ below the mudslide (Brunskill et al. 1973).

Sediment released to flowing water as a result of pipeline construction can affect fish populations in several ways. Cordone and Kelly (1961) indicate that increased sediment loads on streams have a deleterious effect on bottom fauna, and that the reduction in bottom fauna abundances and diversity can adversely affect a salmonid fish population. Brunskill et al. (1973) found that naturally tubrid, silt laden rivers and lakes supported a less abundant and diversified invertebrate fauna and flora than did aquatic systems with low concentrations of suspended sediment. Sediment rich in organic matter is often more harmful to benthic organisms in aquatic environments than inorganic sediments (Guy and Ferguson 1970).

Phillips (1971) reports that when sediment settles on gravel spawning beds, it fills the gravel interstices thereby reducing interchange between surface waters and waters within the gravel bed. This reduces the supply of dissolved oxygen to the egg, and interferes with the removal of metabolites. Sediment also forms a barrier to fry emergence by blocking the route of egress. Saunders and Smith, 1965 report that standing crops of brook trout (Salvelinus fontinalis) were closely associated with silting in Ellerslie Brook, Prince Edward Island and appeared to result from the destruction of hiding places. Spawning was also curtailed by silting.

Cordone and Kelly (1961) and Gammon (1970) indicate that while eggs and fry are quite susceptable to the direct action of suspended sediment, juveniles and adults are quite resistant and are capable of enduring temporary periods of high concentrations of suspended solids. Although some non salmonid fish species have been shown to survive exposures to more than 100,000 $mg \cdot L^{-1}$ for a week or longer (Wallen 1951) more recent bioassays conducted by Noggle (1978) seem to indicate a much higher susceptability of wild chinook salmon (Oncorhynchus tshawytscha), coho salmon (Oncorhynchus kisutch) and steelhead trout (Salmo gairdneri) for suspended sediment. Tolerance to natural stream sediment varied seasonally and 50 percent of the fish exposed to concentrations of suspended solids at 1250 $mg \cdot L^{-1}$ during August failed to survive for 96 hours.

A number of investigators have indicated that suspended sediment damages gill membranes, causing death where concentrations are high and exposure is prolonged (Herbert et al. 1961; Phillips 1971). Herbert and Merkens (1961) observed thickening and fusion of secondary gill lamellae of some rainbow trout (Salmo gairdneri) exposed for several weeks to diatomaceous earth or chiny clay. Noggle (1978) reported notable gill histopathologies in certain juvenile salmonid fish held in inorganic sediment suspensions <13,000 $mg \cdot L^{-1}$ for up to 96 hours.

Most recently McLeay et al. (1983) ran a series of controlled laboratory and on-site field bioassays to examine the acute effects of suspended Yukon placer mining sediment on young-of-the-year Arctic grayling. Wild Arctic grayling, captured as swimup fry or young fingerlings were acclimated to warm water (15°C) or coldwater (5°C) conditions before laboratory testing. Laboratory bioassays demonstrated that young-of-the-year Arctic grayling can survive short-term exposure to very high levels (≈50,000 $mg \cdot L^{-1}$) of suspended or organic sediment. Season did not cause any marked changes in this tolerance, although a slight reduction in lethal tolerance to suspensions of inorganic material was suggested for grayling acclimated to cold (5°C) water. Fish survival data for grayling held in turbid waters downstream of placer mining activity for 4 or 5 days during August and September were consistent with laboratory findings. No gill histopathologies were found in either laboratory or field tests which could be attributed to acute exposure of Arctic grayling to sediment. Additionally, the laboratory bioassays indicated that the tolerance of grayling to hypoxic conditions or to upper lethal tem-

peratures was not appreciably affected by suspension of inorganic or organic sediment.

It has been demonstrated that fish exposed to levels of suspended solids, below those found to be lethal, have reduced oxygen uptake and impaired swimming ability (Smith et al. 1966; MacLeod and Smith 1966). If low levels of suspended solids affect fish through interference with oxygen exchange, it would be expected that such levels would be especially detrimental under conditions of low oxygen content. This could have important implications to fish populations subjected to increased suspended sediment while under winter ice at a time when oxygen content is low. Porter et al. (1974) felt that winter is likely to be a critical period for river biota because of the harsh conditions found by resident populations. These include a reduced discharge, confined river channel, and low oxygen concentration.

Berger (1977) believed that numerical standards for sediment loading were required as a guide for those concerned with the design, review, construction and operation of a pipeline. He indicated that the following standard should be used to determine allowable levels of finely-divided solids in water: "at the specified distance from operations, turbidity of the water shall not average more than 27 times the natural level during any 8-hour period, or more than 9 times the natural level during any 96-hour period, or more than 3 times the natural level during any 30-day period." Our data indicate that Berger's (1977) guidelines were probably all exceeded in the case of the Hodgson Creek pipeline crossing in 1985. This is because of the extremely high suspended sediment concentrations produced relative to background levels and the averaging provision of the guidelines.

The highest natural concentration we found in Hodgson Creek was 369 $mg \cdot L^{-1}$ on June 1, 1985 at Station U2, however, this value should not be considered indicative of high values which occur during spring freshet. Spring freshet values probably meet or exceed those recorded during pipeline construction but it must be kept in mind that what is tolerable in spring when natural sediment loads are normally high may be unacceptable in winter when most northern rivers are relatively clear (Campbell et al. 1975).

Temperature

Water temperatures are provided for Hodgson Creek in Table 4. The temperature of water as it flows from the ground at Station S2 in mid-winter is approximately 5.0°C. This temperature then falls until it reaches 0°C at some point between Stations U1 and D1 and the stream becomes ice-covered.

Pipeline construction had no discernible effect on water temperature in Hodgson Creek.

Dissolved oxygen

Dissolved oxygen levels are presented in Table 5. In all samples dissolved oxygen was at or near saturation. As would be expected with turbulent flow not covered by ice, dissolved oxygen levels increase downstream as water temperature drops. However, in streams covered by winter ice, concentrations of suspended sediment and discharge usually fall to very low values. Oxygen concentrations are frequently very low under these conditions and temperatures are close to 0°C. To add sediment, containing organic matter, to a stream during this period would likely further reduce O_2 concentrations possibly to levels lethal to aquatic biota. Brunskill et al. (1973) found that oxygen concentrations decreased to less than 50% saturation in some small streams, which was probably due to the natural transport of dissolved and particulate organic matter under winter ice.

Pipeline construction or operation has had no discernable effect on dissolved oxygen levels during our study.

Nutrient elements, cations, anions, and miscellaneous measurements

Data from all analyses performed are provided in Table 6. All data fall within ranges provided by Brunskill et al. (1973) and Campbell et al. (1975) for Mackenzie River watersheds. Pipeline construction activities appear to have little effect on concentrations of any of the parameters measured.

FISH

Many studies have attempted to identify "critical areas" for fish populations inhabiting streams along proposed pipeline routes in the Northwest Territories and Yukon (eg. McCart et al. 1974; Craig and McCart 1974; McCart and McCart 1982). In general, these are areas in which fish populations spawn and/or overwinter. Especially critical are localities where the eggs, juveniles and adults of fall spawning species such as Arctic char (Salvelinus alpinus) and round whitefish (Prosopium cylindraceum) all occupy a small area of stream for many months during the course of the winter (Craig and McCart, 1974). Any activity which detrimentally affects water quality in such an area might have serious consequences for the entire population.

We found that the Hodgson Creek headwaters contain Arctic grayling (Thymallus arcticus), slimy sculpin (Cottus cognatus) and a small number of lake chub (Couesius plumbeus), longnose sucker (Catostomus catostomus), burbot (Lota lota) and northern pike (Esox lucius) during winter. We found no evidence of fall spawners in our study area during any time of year. McCart et al. (1974) believed that the headwaters of Hodgson Creek contain a resident population of Arctic grayling and slimy sculpin and that the lower reaches of Hodgson Creek is a spawning and rearing area for Arctic grayling, round whitefish, longnose sucker and lake chub. Although it was not possible to demonstrate any direct effect of construction activities on spawn in situ, we believe that data collected on suspended sediment and sedimentation rates as well as O_2 and discharge can be extrapolated to

other sites where this "critical" habitat exists.

Hodgson Creek does not contain an entire population of fish in a confined area downstream of the construction area and as such we are not able to describe a direct effect on such a population. The highest concentrations of fish in winter are found in pools in the open water area of Hodgson Creek from Station S2 to Station U1. Ice-covered areas downstream of the pipeline from Stations D1 to D5 also harbour fish during winter but our sampling in these areas indicates that numbers are not high and fish do not congregate there. We believe that flow in Hodgson Creek is cut off by aufeis fields which begin to form at Station D3 and build up downstream.

In order to ascertain whether any downstream emigration would occur as a result of construction activities a hoop net was maintained for a one week period approximately 1.2 km downstream (Station D5) of the pipeline right-of-way in 1985. We believe that the net blocked off the stream completely and effectively captured all downstream emigrants. The total hoop-net catch over the period February 14 to 20 was 19 fish (Table 7, Column D5). Based on our observations, we do not believe that the number of fish captured represents a high proportion of the number of fish occupying the area between the pipeline crossing and Station D5. Therefore, we attribute this catch to local movement of individual fish rather than a mass emigration from upstream areas.

Arctic grayling

The life cycle of Arctic grayling in the Mackenzie Valley is complicated and aspects of its seasonal movements are not fully delineated and may vary for different populations (Stein et al. 1973). Generally speaking, mature Arctic grayling move into tributaries of the Mackenzie River in the spring to spawn. They then either move back down to the Mackenzie River in late spring or spend the summer feeding in tributaries and usually move downstream prior to freeze-up. In many small tributaries which freeze completely during winter, both summer resident adult and juvenile fish move out to overwintering areas presumably in the Mackenzie River.

On the Yukon North Slope perennial ground springs provide overwintering areas for both mature and juvenile Arctic grayling (de Bruyn and McCart 1974). These sites are of special importance to fish of the Yukon North Slope because during winter most streams (which flow directly to the Beaufort Sea) freeze completely. In the case of the Mackenzie River, however, the mainstem itself provides an alternative to overwintering areas in tributary streams such as Hodgson Creek.

Tripp and McCart (1974) describe the Arctic grayling from Hodgson Creek as being the slowest growing population they knew of. Our data on age and length frequency and growth of Arctic grayling taken from Hodgson Creek are provided in Fig. 8 and Fig. 9. We find mean fork length at age, up to age 3, to be comparable to other nearby tributaries as reported by McKinnon et al. (1978, 1982). However, resident Arctic grayling (captured in Hodgson Creek during winter) have a lower mean fork length at age 3 and 4 years than do fish of corresponding age caught in the previous summer in Hodgson Creek or nearby Smith Creek (McKinnon et al. 1978, 1982).

Tripp and McCart (1974) describe the Arctic grayling in the headwaters of Hodgson Creek as probably being a resident population because adult and juvenile Arctic grayling were present throughout the summer and winter. They found the youngest mature Arctic grayling in Hodgson Creek to be age 5. Our data indicate the overwintering group of Arctic grayling in Hodgson Creek to be comprised entirely of young-of-the-year and juveniles up to age 4 (Fig. 10). We captured age 5 or older Arctic grayling in Hodgson Creek in summer only.

Our data would suggest that there is a part of the Hodgson Creek Arctic grayling population which remains resident year-round in the headwaters of Hodgson Creek up until age 3 or 4. With the onset of maturity these previously resident Arctic grayling apparently move farther afield and begin to overwinter elsewhere, probably in the Mackenzie River. Under this scenario Hodgson Creek contains both migratory and non-migratory Arctic grayling in summer while in winter it supports only that segment of the population which has not yet become migratory. This might explain the smaller mean size of winter-caught 3 and 4-year old Arctic grayling from Hodgson Creek when compared to those captured the previous summer.

Stomach content analyses are provided for the years 1983 through 1986 (Tables 9, 10, 11, 12). These are broken down into fork length intervals and seasonal categories. Arctic grayling are generally described as being opportunistic feeders and those in Hodgson Creek appear to be no exception. The summer diet for Arctic grayling in Hodgson Creek is quite varied with Diptera adults and larvae, Hymenoptera adults and Plecoptera generally comprising a large proportion of the diet. There is a tendency towards greater surface feeding on the part of larger Arctic grayling in summer with these feeding on adult forms of terrestrial and aquatic insects and spiders; small grayling tend to feed on drift and bottom organisms to a greater degree. During winter, the available food source is more limited since terrestrial insects are generally not available; Diptera larvae and Plecoptera then comprise most of the diet.

Slimy sculpin

Slimy sculpin were present at all locations and during all sampling periods in our study area. A length frequency histogram is presented in Fig. 11 and compares summer and winter samples.

Analysis of stomach contents revealed a large number which were empty or contained unidentifiable remains. For those which contained identifiable remains, Plecoptera and Diptera larvae were the food items in greatest

abundance. Slimy sculpin in Hodgson Creek also fed upon Trichoptera and, to a lesser extent, on other slimy sculpin. Two stomachs were analyzed from slimy sculpin captured during winter; of these one was empty and one contained 163 Diptera larvae (Orthocladinae).

Lake chub

Twenty-seven lake chub were captured over the period of study and a length frequency for these is provided in Fig. 11.

During summer, lake chub were found to feed on a wide range of both aquatic and terrestrial insects. One stomach, analyzed from the winter of 1985, contained one Plecoptera and one Trichoptera.

Longnose sucker, burbot, northern pike

Small numbers of each of these species have been captured in Hodgson Creek year round.

The stomach contents of longnose sucker were not analyzed. Burbot were found to feed primarily on Plecoptera, Arctic grayling and slimy sculpin. Northern pike fed on Arctic grayling predominantly.

CONCLUSIONS

1. Pipeline sag bends were not located outside of the potential channel boundaries at the Hodgson Creek crossing. As a result of rainfall in June 1986 Hodgson Creek shifted northward at the pipeline crossing to a point near to or outside of the area protected by deep burial and saddle weights. In 1987, two years after initial construction of the Hodgson Creek pipeline crossing, training works and excavation of a new stream channel became necessary at the crossing site in order to correct for stream channel shift.

2. Construction of a pipeline crossing and operation of an ambient temperature pipeline at Hodgson Creek has had no discernible effect on stream discharge or velocity. No icings were created and flow was not diverted from the natural stream channel.

3. In the twenty-four hours following completion of the Hodgson Creek pipeline crossing, sediment deposition averaged 140 $mg \cdot hr^{-1}$ in collectors placed approximately 50 m downstream of the alignment. This compares to a pre-construction value of <1 $mg \cdot hr^{-1}$ and an average value during construction of 42 $mg \cdot hr^{-1}$. Percent organic content decreased during times of high deposition. Two days after back-filling of the trench the deposition rate averaged 1 to 2 $mg \cdot hr^{-1}$ over a twenty-four hour period.

4. Winter bridge construction increased the suspended sediment (TSS) level from a pre-construction value of 2 $mg \cdot L^{-1}$ to a recorded high of 26 $mg \cdot L^{-1}$, 50 metres downstream of the crossing site. Seven hours after this peak the TSS value at this site again approximated the pre-construction value.

5. Pipeline trenching across Hodgson Creek produced an increase in suspended sediment (TSS) concentration from 1 $mg \cdot L^{-1}$ prior to construction to a maximum of 3524 $mg \cdot L^{-1}$, 50 m downstream, on February 16, 1985. High suspended sediment levels attenuated quickly both over time and distance. Other construction activities including pipe-laying and back-filling produced lesser increases in TSS than did trenching. On February 21 the suspended sediment value 50 m downstream of pipeline crossing was equal to the value at sites upstream of the crossing.

6. The headwaters of Hodgson Creek provide winter habitat for Arctic grayling, slimy sculpin and a small number of lake chub, longnose sucker, burbot and northern pike. No fall spawners utilize the headwaters of Hodgson Creek for spawning, therefore there is no spawn in situ during winter.

7. Winter pipeline construction across the headwaters of Hodgson Creek had no direct immediate effect on the fish which reside there during winter. Pipeline crossing activities did not lead to downstream emigration and no mortality was observed.

8. The Arctic grayling which overwinter in the headwaters of Hodgson Creek do not constitute a resident population since adults overwinter elsewhere. No Arctic grayling over age 4 were found in Hodgson Creek during winter and we found the youngest mature Arctic grayling to be age 5.

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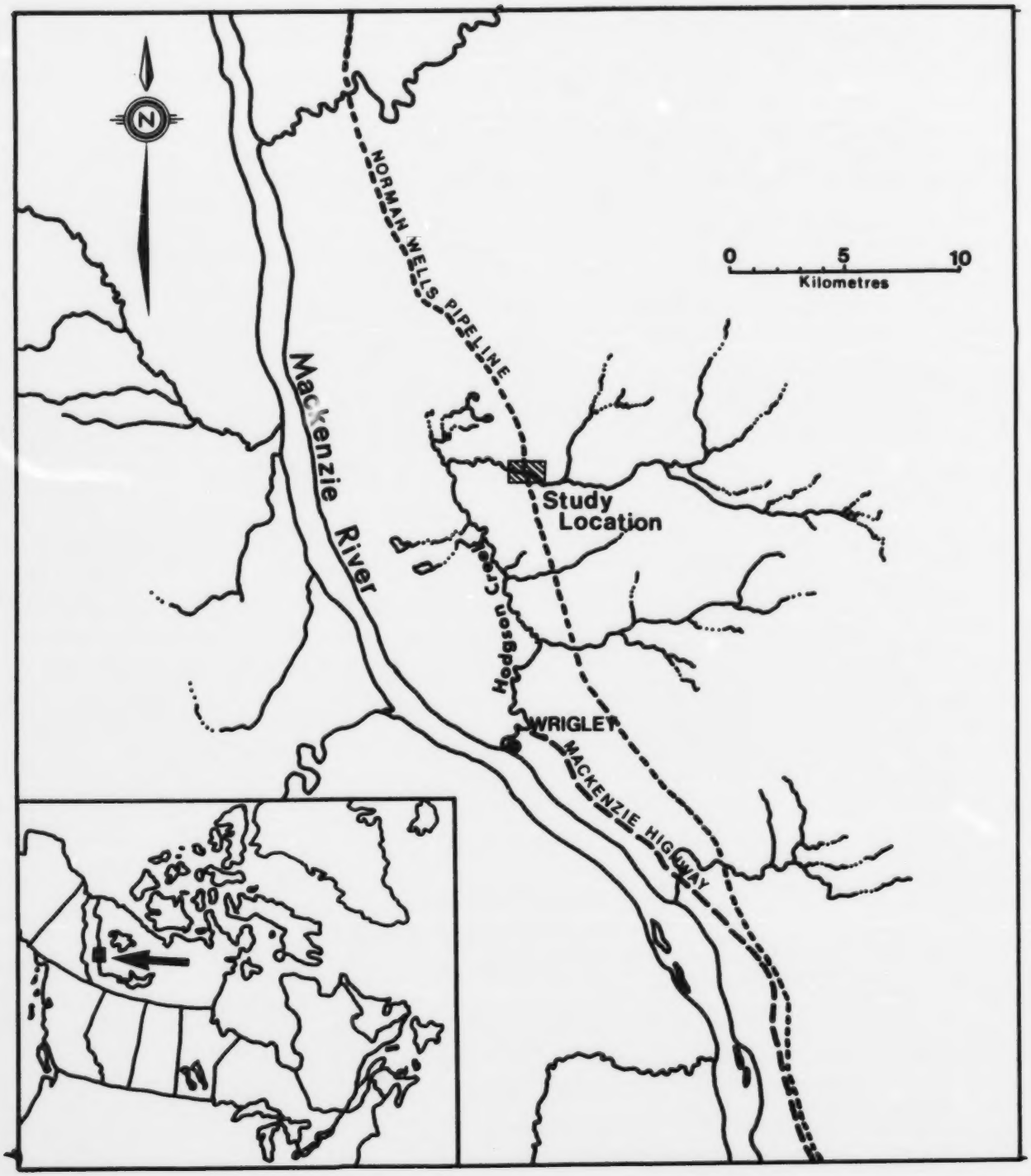


Fig. 1. Map of the Northwest Territories showing the Norman Wells pipeline alignment near Wrigley.

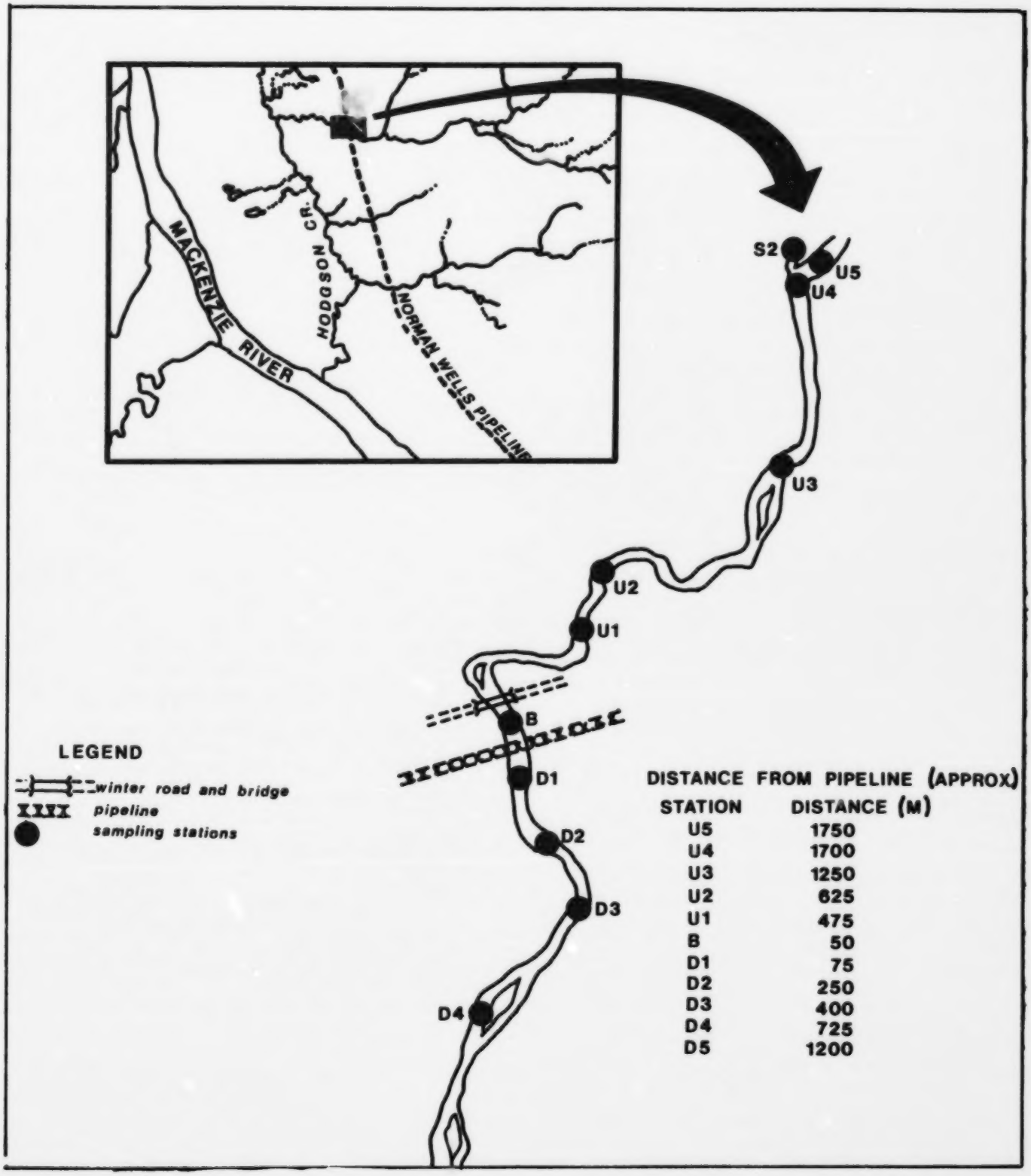
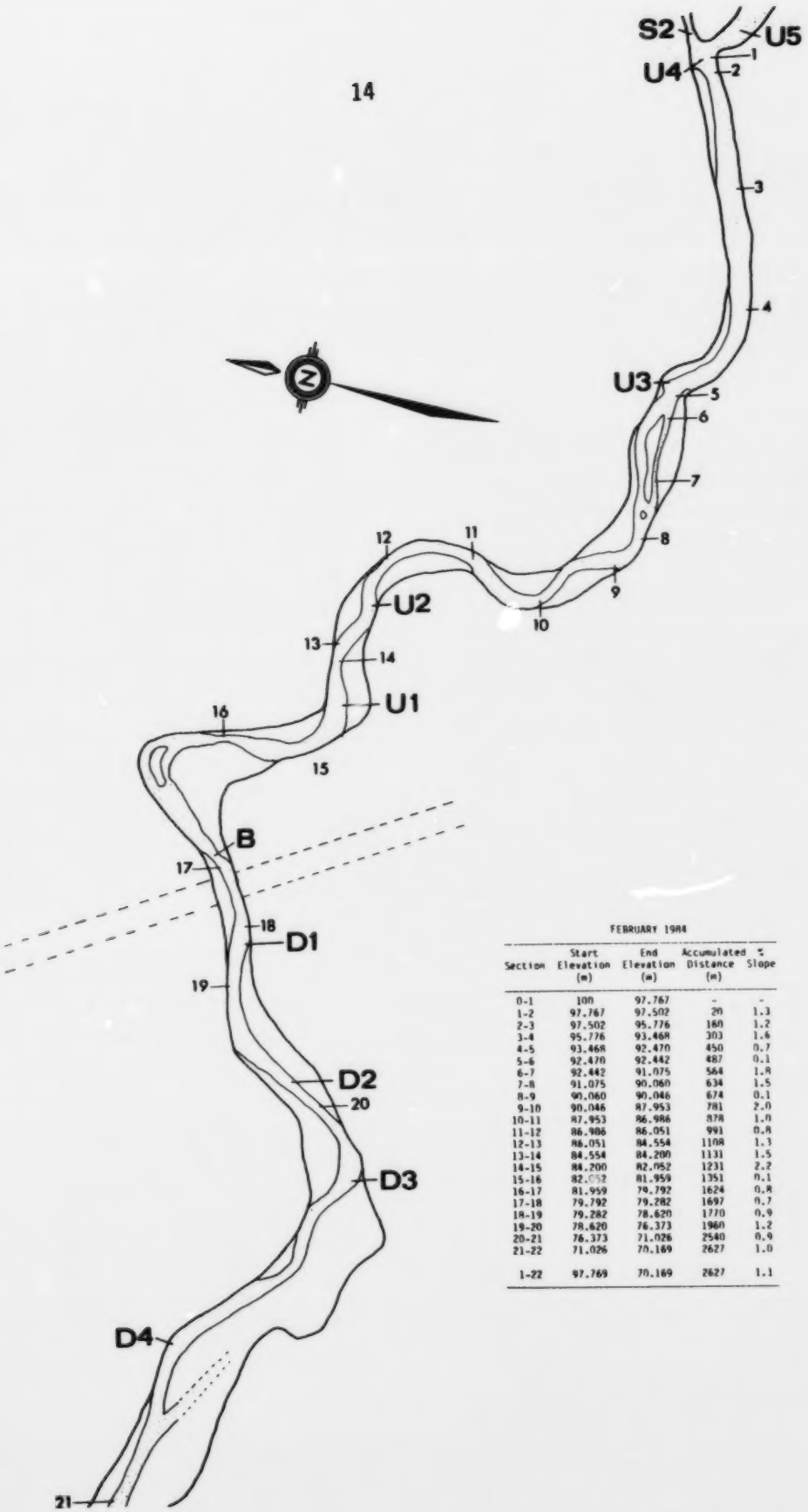


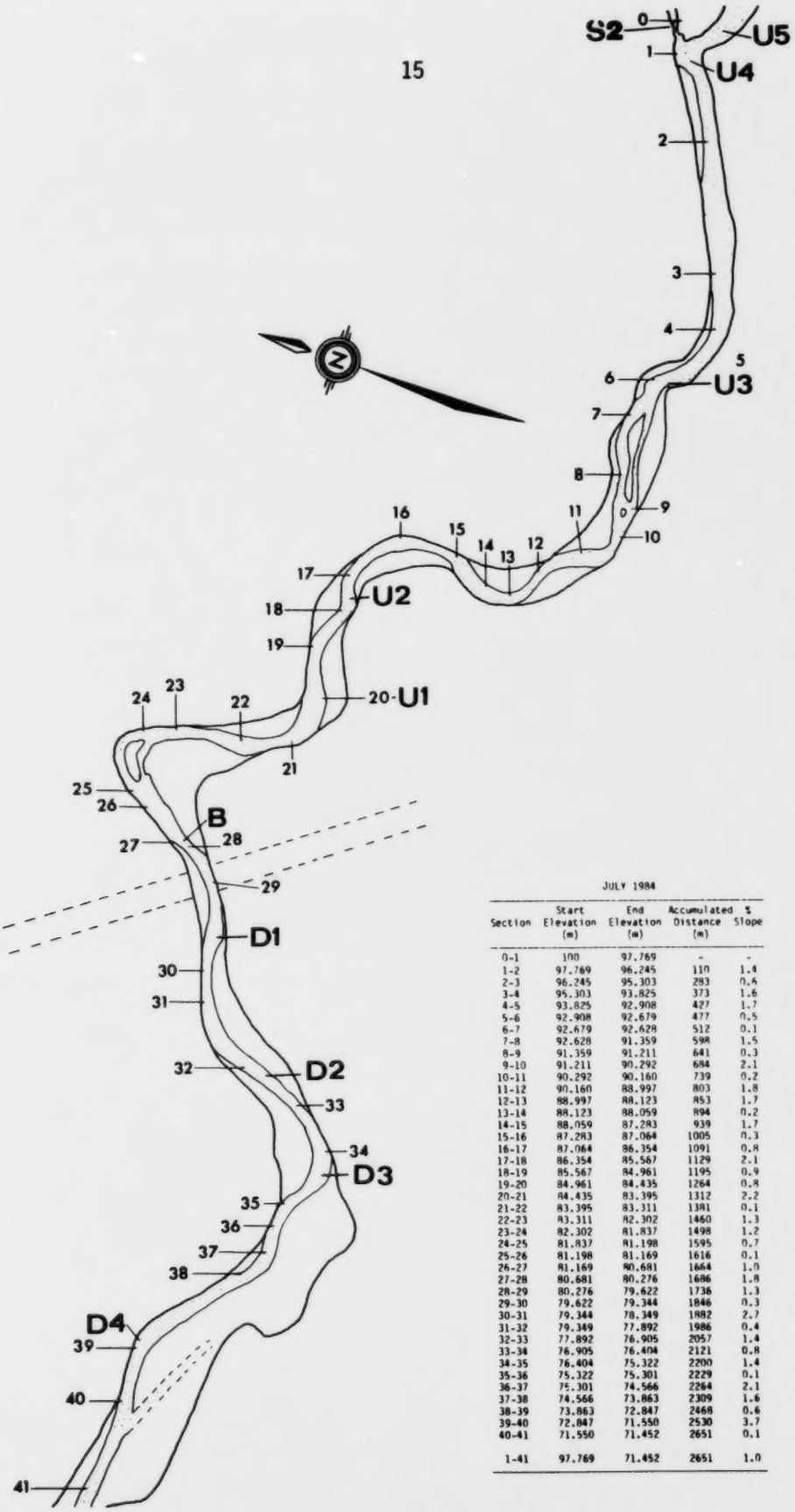
Fig. 2. Map of the study area showing sampling locations.



FEBRUARY 1984

Section	Start Elevation (m)	End Elevation (m)	Accumulated Distance (m)	% Slope
0-1	100	97.767	-	-
1-2	97.767	97.502	20	1.3
2-3	97.502	95.776	160	1.2
3-4	95.776	93.468	303	1.6
4-5	93.468	92.470	450	0.7
5-6	92.470	92.442	487	0.1
6-7	92.442	91.075	564	1.8
7-8	91.075	90.060	634	1.5
8-9	90.060	90.046	674	0.1
9-10	90.046	87.953	781	2.0
10-11	87.953	86.986	878	1.0
11-12	86.986	86.051	991	0.8
12-13	86.051	84.554	1108	1.3
13-14	84.554	84.200	1131	1.5
14-15	84.200	82.052	1231	2.2
15-16	82.052	81.959	1351	0.1
16-17	81.959	79.792	1624	0.8
17-18	79.792	79.282	1697	0.7
18-19	79.282	78.620	1770	0.9
19-20	78.620	76.373	1960	1.2
20-21	76.373	71.026	2540	0.9
21-22	71.026	70.169	2627	1.0
1-22	97.769	70.169	2627	1.1

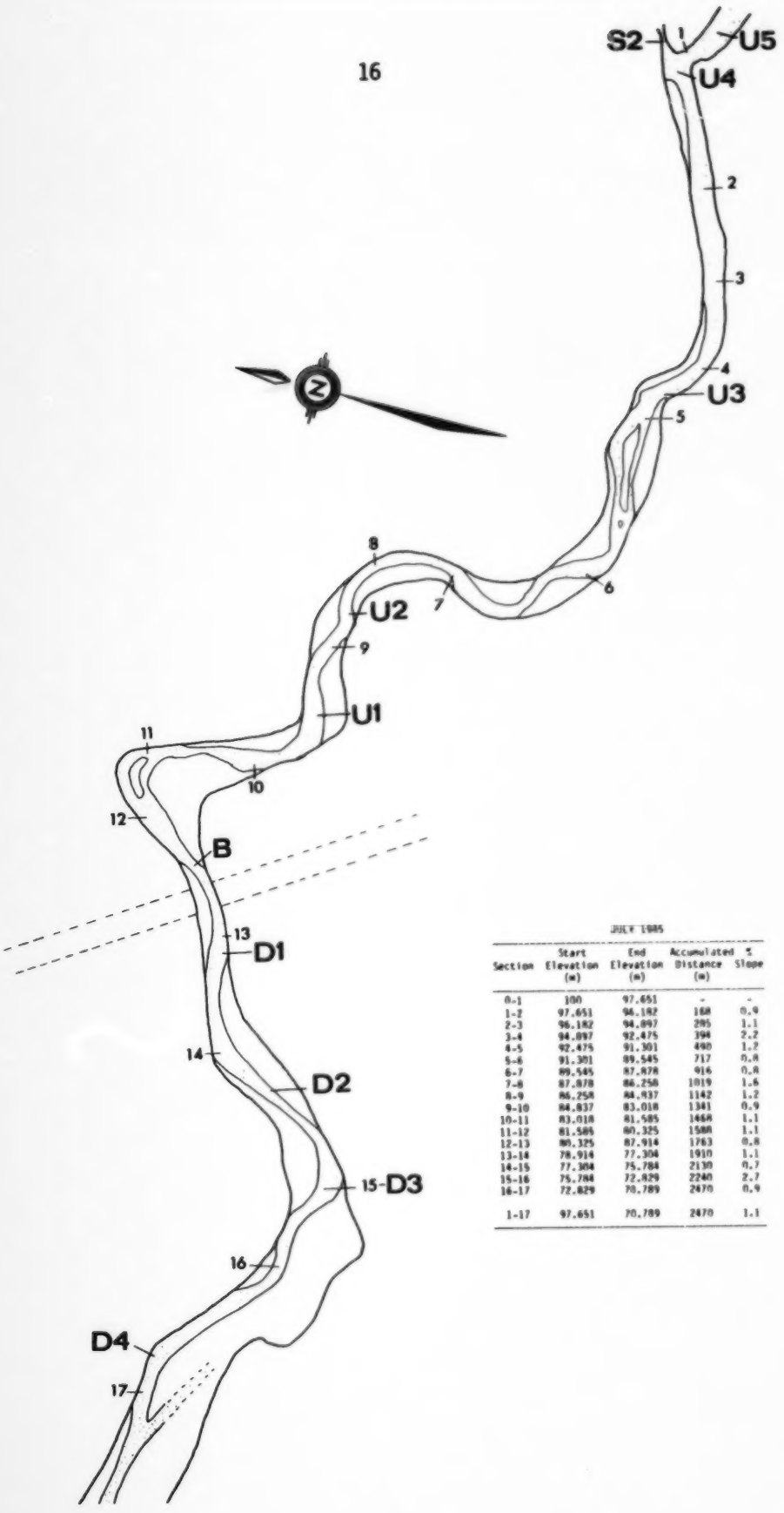
Fig. 3. Map of Hodgson Creek showing stream morphology, relative elevation and slope within the study area, February, 1984.



JULY 1984

Section	Start Elevation (m)	End Elevation (m)	Accumulated Distance (m)	% Slope
0-1	100	97.769	-	-
1-2	97.769	96.245	110	1.4
2-3	96.245	95.303	283	0.6
3-4	95.303	93.825	373	1.6
4-5	93.825	92.908	427	1.7
5-6	92.908	92.679	477	0.5
6-7	92.679	92.628	512	0.1
7-8	92.628	91.359	598	1.5
8-9	91.359	91.211	641	0.3
9-10	91.211	90.292	684	2.1
10-11	90.292	90.160	739	0.2
11-12	90.160	88.997	803	1.8
12-13	88.997	88.123	853	1.7
13-14	88.123	88.059	894	0.2
14-15	88.059	87.283	939	1.7
15-16	87.283	87.064	1005	0.3
16-17	87.064	86.354	1091	0.8
17-18	86.354	85.567	1129	2.1
18-19	85.567	84.961	1195	0.9
19-20	84.961	84.435	1264	0.8
20-21	84.435	83.395	1312	2.2
21-22	83.395	83.311	1381	0.1
22-23	83.311	82.302	1460	1.3
23-24	82.302	81.837	1498	1.2
24-25	81.837	81.198	1595	0.7
25-26	81.198	81.169	1616	0.1
26-27	81.169	80.681	1664	1.0
27-28	80.681	80.276	1686	1.8
28-29	80.276	79.622	1736	1.3
29-30	79.622	79.344	1846	0.3
30-31	79.344	78.349	1882	2.7
31-32	79.349	77.892	1986	0.4
32-33	77.892	76.905	2057	1.4
33-34	76.905	76.404	2121	0.8
34-35	76.404	75.322	2200	1.4
35-36	75.322	75.301	2229	0.1
36-37	75.301	74.566	2264	2.1
37-38	74.566	73.863	2309	1.6
38-39	73.863	72.847	2468	0.6
39-40	72.847	71.550	2530	3.7
40-41	71.550	71.452	2651	0.1
1-41	97.769	71.452	2651	1.0

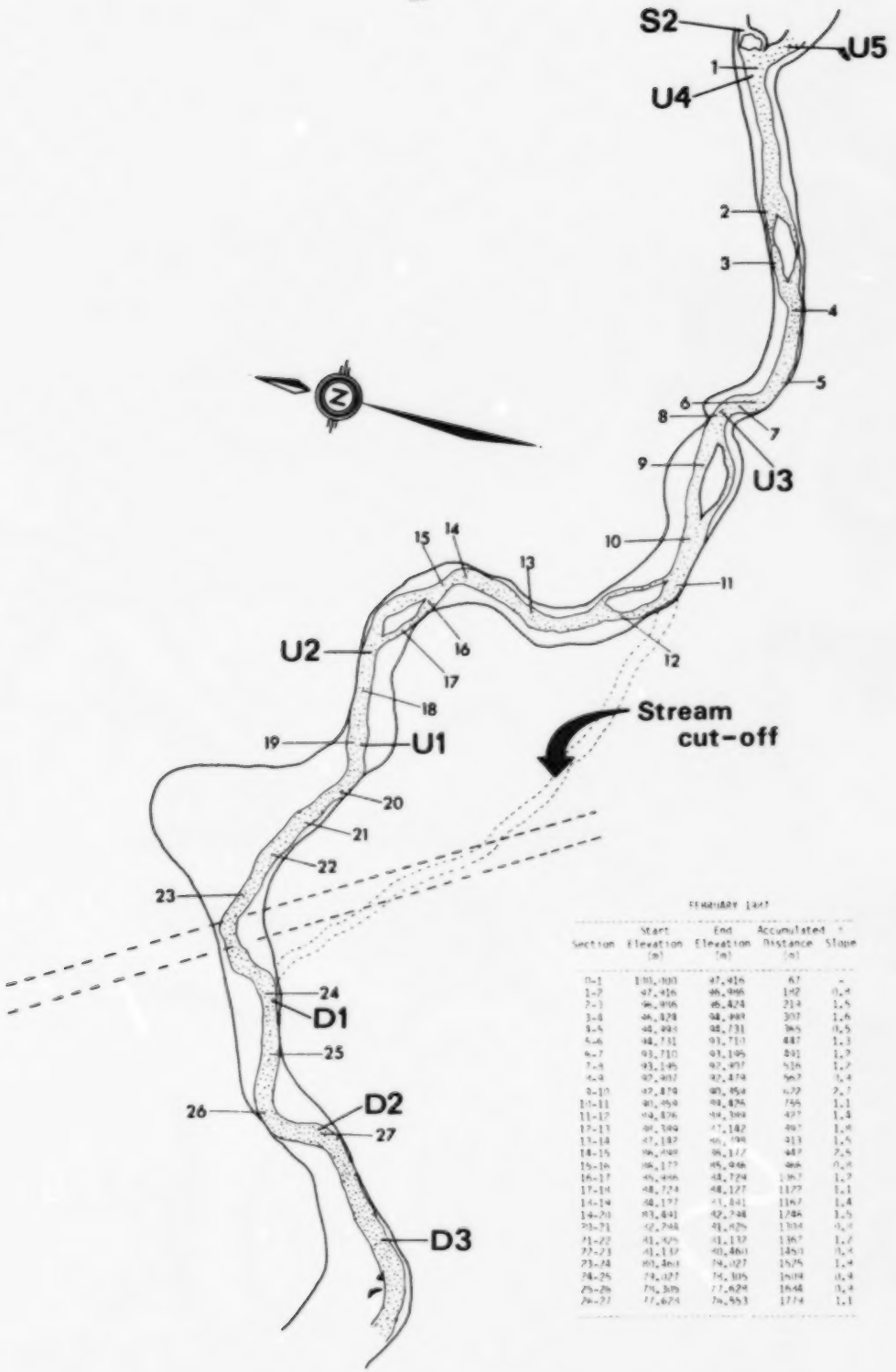
Fig. 4. Map of Hodgson Creek showing stream morphology, relative elevation and slope within the study area, July, 1984.



JULY 1985

Section	Start Elevation (m)	End Elevation (m)	Accumulated Distance (m)	% Slope
0-1	100	97.651	-	-
1-2	97.651	96.182	168	0.9
2-3	96.182	94.897	285	1.1
3-4	94.897	92.475	394	2.2
4-5	92.475	91.301	490	1.2
5-6	91.301	89.545	717	0.8
6-7	89.545	87.878	916	0.8
7-8	87.878	86.258	1019	1.6
8-9	86.258	84.937	1142	1.2
9-10	84.837	83.018	1341	0.9
10-11	83.018	81.585	1468	1.1
11-12	81.585	80.325	1588	1.1
12-13	80.325	87.914	1763	0.8
13-14	78.914	77.304	1910	1.1
14-15	77.304	75.784	2130	0.7
15-16	75.784	72.829	2240	2.7
16-17	72.829	70.789	2470	0.9
1-17	97.651	70.789	2470	1.1

Fig. 5. Map of Hodgson Creek showing stream morphology, relative elevation and slope within the study area, July, 1985.



FEBRUARY 1987

Section	Start Elevation (m)	End Elevation (m)	Accumulated Distance (m)	Slope
0-1	100.000	47.416	67	-
1-2	47.416	46.996	142	0.4
2-3	46.996	46.424	214	1.5
3-4	46.424	44.989	307	1.6
4-5	44.989	44.731	365	0.5
5-6	44.731	43.710	447	1.3
6-7	43.710	43.105	541	1.7
7-8	43.105	42.457	626	1.7
8-9	42.457	42.174	567	1.4
9-10	42.174	40.454	672	2.7
10-11	40.454	39.874	766	1.1
11-12	39.874	38.399	877	1.8
12-13	38.399	37.182	987	1.8
13-14	37.182	36.796	1113	1.5
14-15	36.699	36.177	1187	2.5
15-16	36.177	35.946	1266	0.9
16-17	35.946	34.774	1367	1.7
17-18	34.774	34.127	1477	1.1
18-19	34.127	33.841	1567	1.4
19-20	33.841	32.748	1784	1.5
20-21	32.748	31.925	1934	1.7
21-22	31.925	31.137	1967	1.7
22-23	31.137	30.461	1953	1.4
23-24	30.461	29.027	1575	1.4
24-25	29.027	28.305	1619	0.9
25-26	28.305	27.624	1648	1.4
26-27	27.624	26.553	1774	1.1

Fig. 6. Map of Hodgson Creek showing stream morphology, relative elevation and slope within the study area, February, 1987.

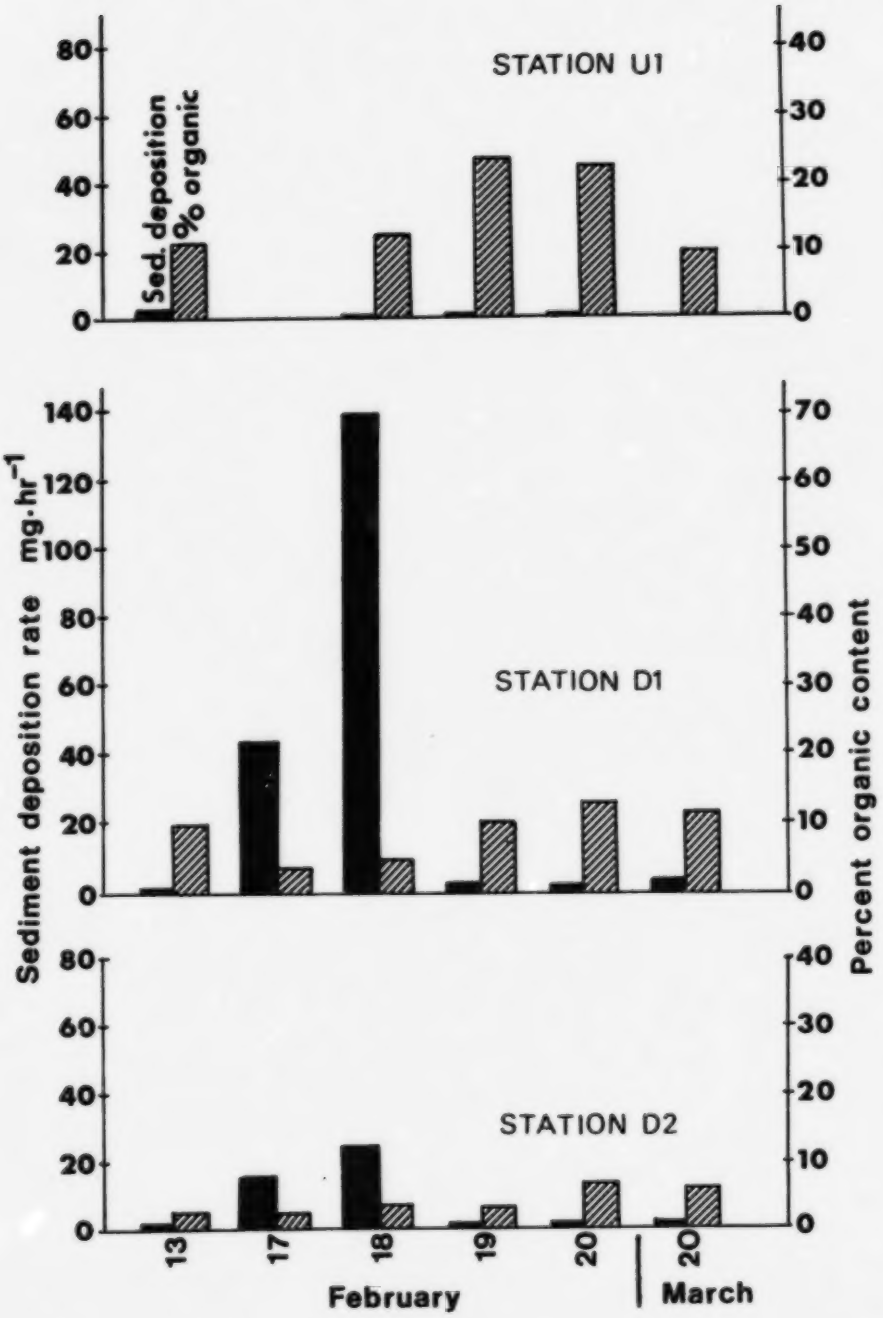


Fig. 7. Sediment deposition rate for collectors installed in Hodgson Creek, 1985.

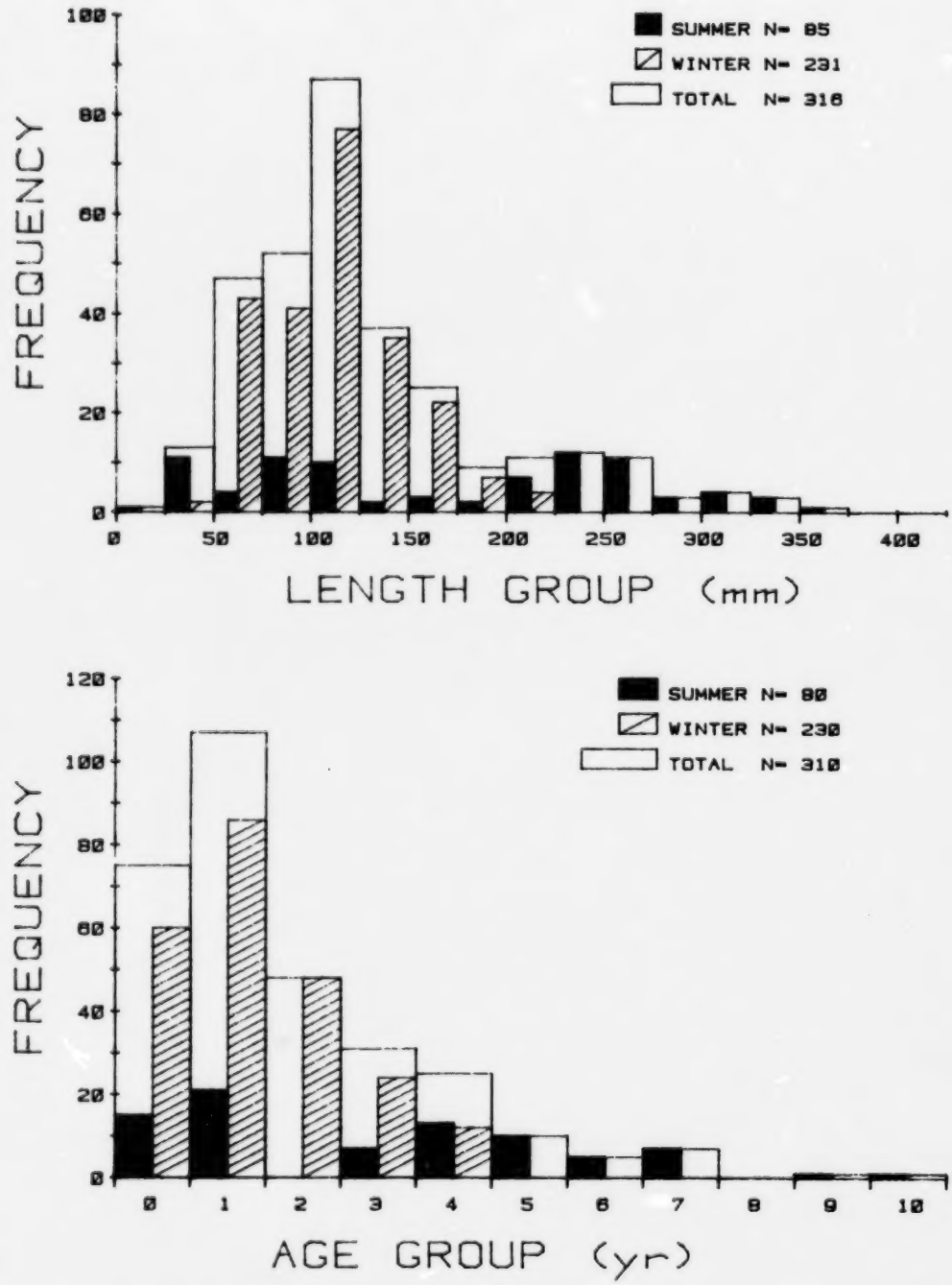


Fig. 8. Seasonal length frequency and age frequency distributions for Arctic grayling from Hodgson Creek, 1983-1986.

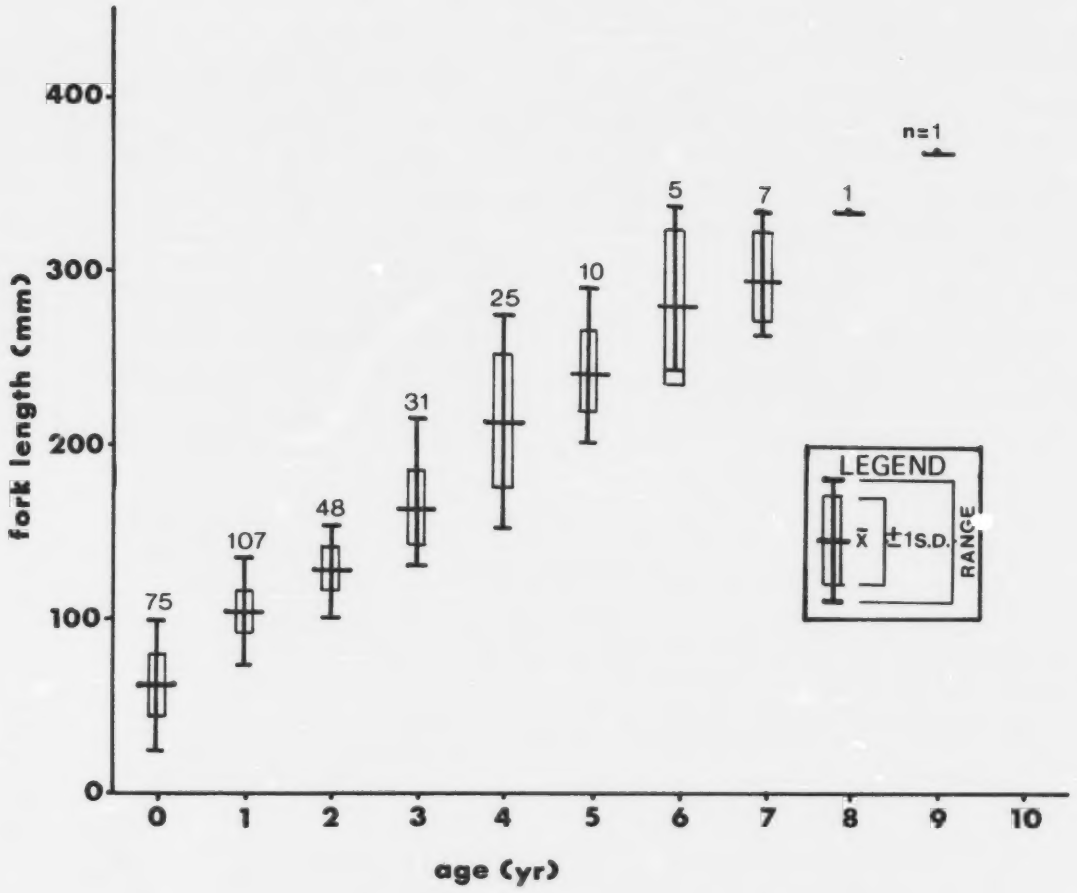


Fig. 9. Growth in length by age for Arctic grayling from Hodgson Creek, 1983-1986.

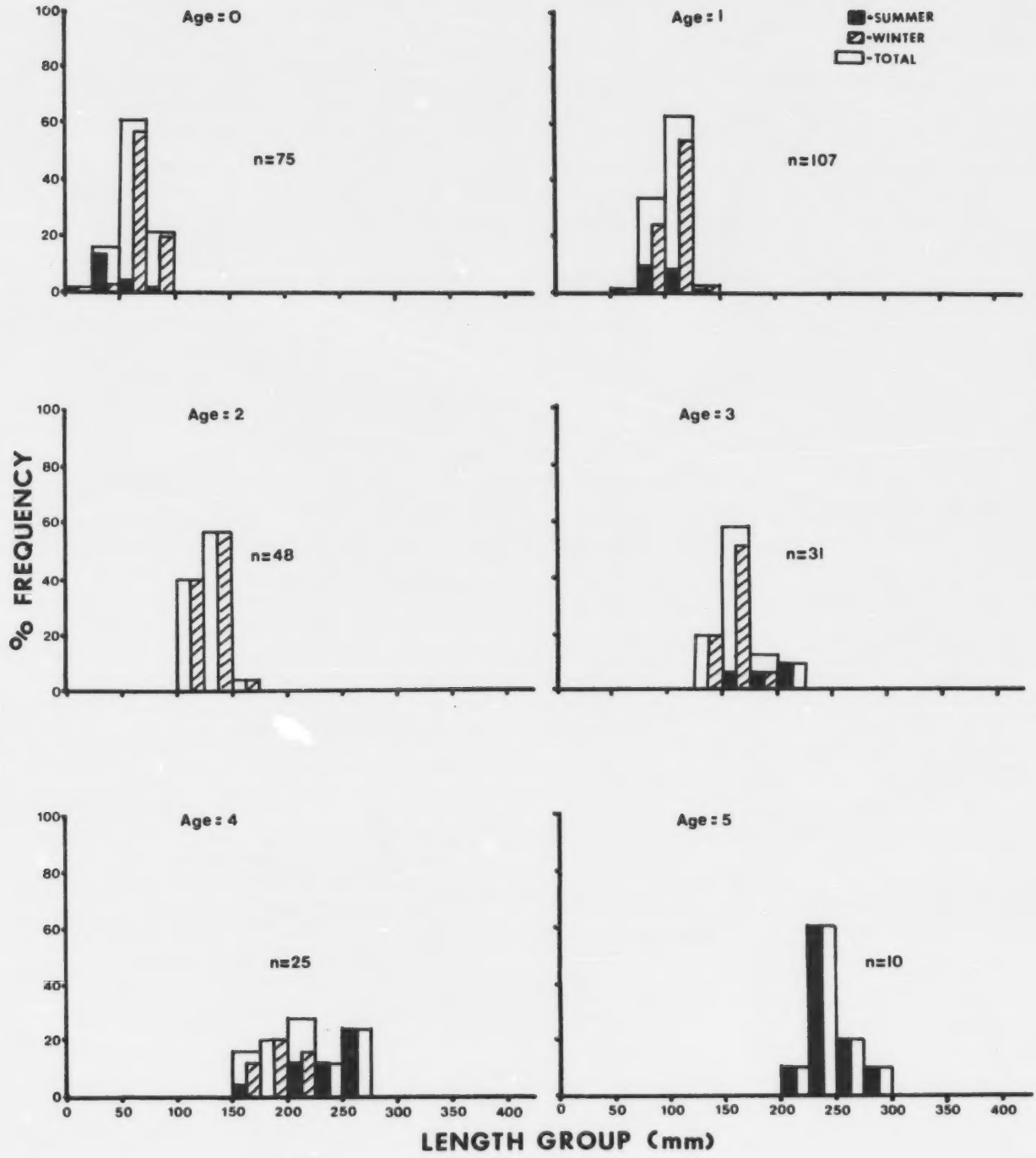


Fig. 10. Seasonal length frequency by age for Arctic grayling from Hodgson Creek, 1983-1986.

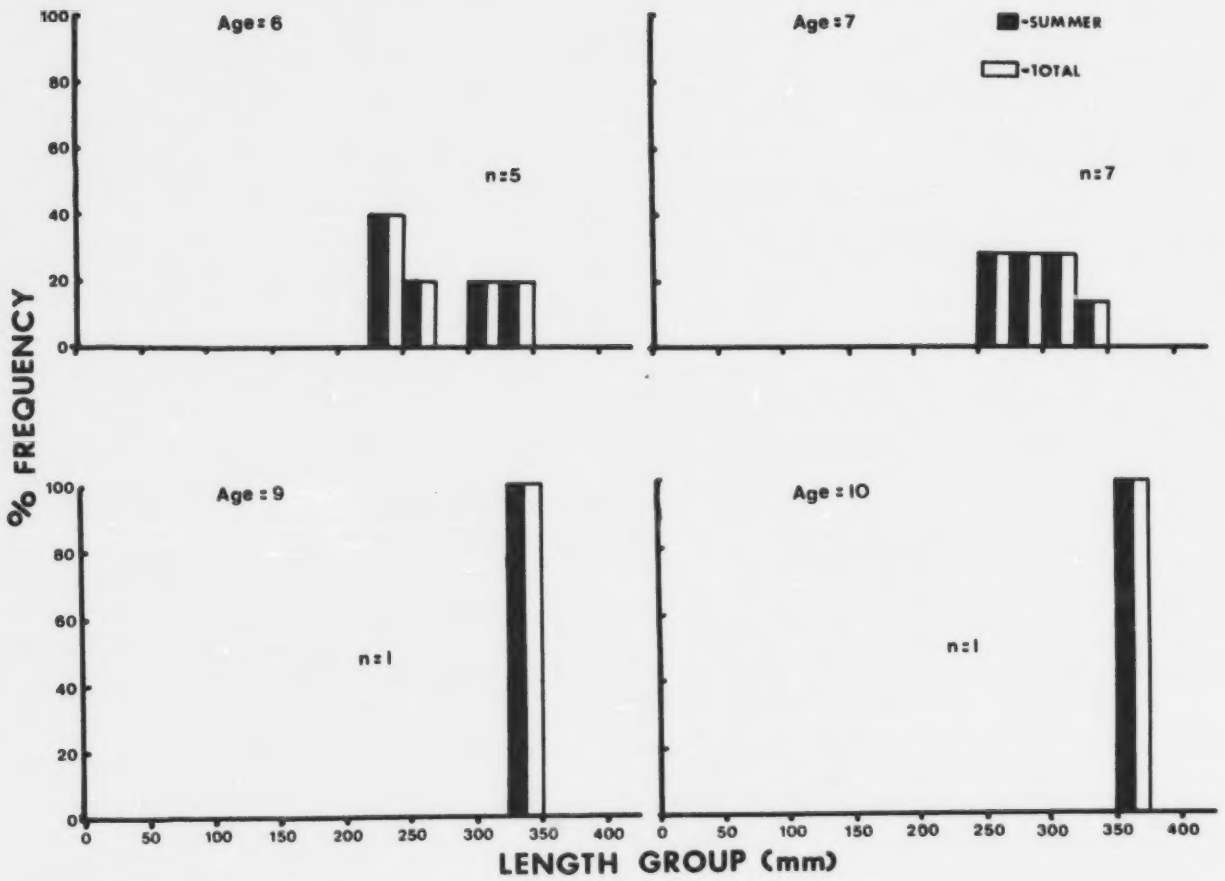

Age: 6
n:5
Age: 7
n:7
■-SUMMER
□-TOTAL
Age: 9
n:1
Age: 10
n:1
% FREQUENCY
LENGTH GROUP (mm)
0
20
40
60
80
100
0
50
100
150
200
250
300
350
400

Fig. 10. Cont'd.

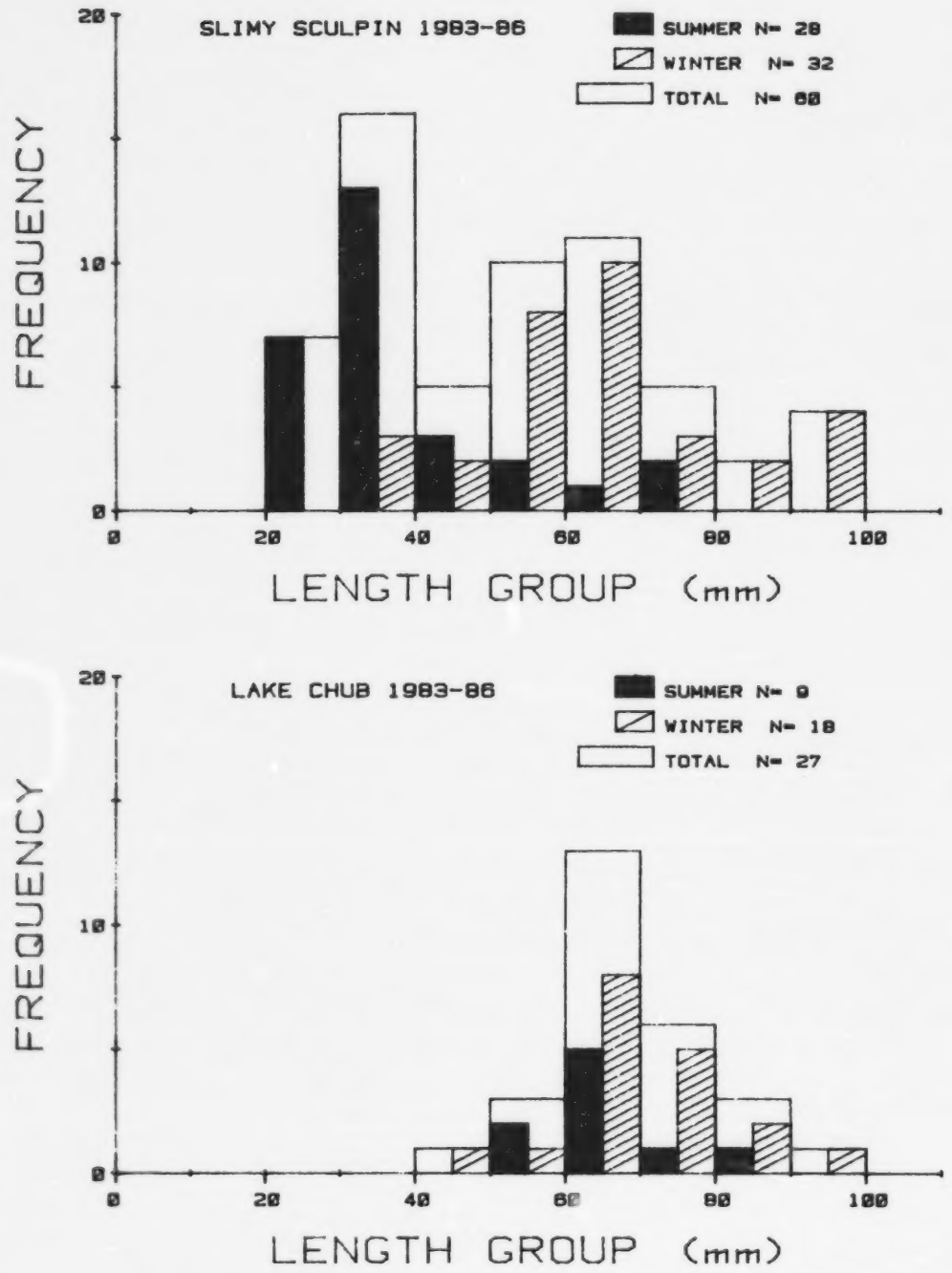


Fig. 11. Seasonal length frequency distributions for slimy sculpin and lake chub from Hodgson Creek, 1983-1986.

Table 1. Summary of sampling periods for Hodgson Creek, 1983 to 1986.

Year			
1983	1984	1985	1986
Sampling Period			
March 25-31	January 30 - February 7	January 19 - February 20	January 30 - February 1
June 4	June 24-July 7	March 19-21	May 30-June 2
July 17-26	August 24-28	May 31-July 21	August 17-19
October 11-20	October 23-25 December 6-7	October 19-20	

Table 2. Discharge ($Q=m^3 \cdot s^{-1}$) and mean cross sectional velocity ($\bar{V}x=m \cdot s^{-1}$) data from Hodgson Creek 1983-1986.

Date			Discharge - Velocity Station U5	S2	U4	U2	U1	D1	D2	D3
1983	June 4	Q						1.97		
		$\bar{V}x$						0.61		
	July 19	Q					0.40			
		$\bar{V}x$					0.31			
	October 20	Q					0.27			
		$\bar{V}x$					0.24			
1984	February 2	Q		0.13		0.13	0.12	0.10	0.09	0.07
		$\bar{V}x$		0.40		0.17	0.14	0.08	0.26	0.09
	March 21	Q		0.14		0.15	0.14	0.16		
		$\bar{V}x$		0.53		0.28	0.13	0.08		
	June 26	Q	0.42	0.13				0.45		
		$\bar{V}x$	0.32	0.24				0.30		
	29	Q	2.05	0.08					1.81	
		$\bar{V}x$	0.83	0.06					0.66	
	July 3	Q	4.67							
		$\bar{V}x$	0.88							
	4	Q	2.76	0.09						
		Vx	0.89	0.06						
	5	Q	1.72	0.11						
		$\bar{V}x$	0.84	0.10						
	6	Q		0.09	1.82					
		$\bar{V}x$		0.10	0.50					
	August 24	Q		0.16	1.48					
		$\bar{V}x$		0.25	0.73					
	28	Q						1.41		
		$\bar{V}x$						0.51		
	October 23	Q		0.13	0.76		0.71			
		$\bar{V}x$		0.21	0.60		0.34			
	24	Q						0.71		0.70
		$\bar{V}x$						0.35		0.44
	December 6	Q					0.18			
		$\bar{V}x$					0.13			
	7	Q		0.15			0.18			
		$\bar{V}x$		0.41			0.13			
1985	January 24	Q		0.17			0.11			
		$\bar{V}x$		0.54			0.09			
	February 2	Q		0.16			0.11			
		$\bar{V}x$		0.53			0.08			

Table 2 Continued.

Date			Discharge - Velocity Station U5	S2	U4	U2	U1	D1	D2	D3
1985	February 19	Q		0.16			0.14			
		Vx		0.51			0.10			
	March 25	Q					0.16			
		Vx					0.10			
	June 1	Q							4.00	
		Vx							0.74	
	7	Q		0.13						
		Vx		0.07						
	19	Q							2.39	
		Vx							0.62	
	27	Q		0.12			1.86		1.82	
		Vx		0.81			0.43		0.48	
	July 8	Q							0.88	
		Vx							0.32	
	16	Q							0.59	
		Vx							0.25	
	October 20	Q		0.19	0.37				0.31	
		Vx		0.33	0.26				0.23	
1986	January 30	Q		0.20			0.20	0.20		
		Vx		0.32			0.12	0.14		
	May 30	Q		0.17	2.91			2.65		
		Vx		0.16	0.85			0.67		
	August 17	Q		0.11	2.13			2.00		
		Vx		0.08	1.09			0.99		

Table 3. Total suspended solids $mg.l^{-1}$ and percent organic content from Hodgson Creek, 1983-1986.

Analysis - Total Suspended Solids ($mg.L^{-1}$)/PERCENT ORGANIC[1]

Date		Time	Station U5		S2		U2		U1		B		D1		D2		D3		D4		D5	
			$mg.L^{-1}$	%	$mg.L^{-1}$	%	$mg.L^{-1}$	%	$mg.L^{-1}$	%	$mg.L^{-1}$	%	$mg.L^{-1}$	%	$mg.L^{-1}$	%	$mg.L^{-1}$	%	$mg.L^{-1}$	%	$mg.L^{-1}$	%
1983	March 28																					
	31																					
	June 4																					
	October 20												29									
													1									
1984	February 2				<1		1		1				1		1							
	March 20						1		5				1		<1		7		1			
	July 6		9	9	1	54	8	13	7	13			9	15	11	12	11	11				
	August 25[2]						4	11	3	13			3	10	2	15	3	20				
	28				<1	100	6	13	5	15			6	12	5	33	5	12				
	October 16[2]						2	43	1	96			2	71	2	87	1	100				
	25				1	50	2	24	2	31			2	25	2	27	2	26				
	December 6	08:45							<1	84	<1	66										
		08:45							<1	76	<1	68										
		10:00							<1	100	5	11	1	20	5	9						
		10:00							<1	61	2	14	2	15	4	13						
		17:50							<1	72	26	43	4	41	2	41						
		17:50							<1	65	22	43	3	43	1	47						
	7	01:00							<1	52	1	28	1	40	1	50						
		01:00							<1	64	2	36	1	26	1	58						
		09:00							3	55	4	16	1	38	<1	50						
		09:00							<1	41	1	41	3	38	1	63						
		17:00							<1	49	1	21	1	58	<1	68						
		17:00							<1	65	1	52	1	48	1	59						
	8	09:30							<1	100	<1	79	14	7	2	19						
		09:30							<1	93	<1	25	18	8	3	21						
		16:00							<1	100	1	26	1	44	1	51						
		16:00			<1	100			1	85	1	100	1	90	1	100						
1985	January 24				20	8			<1	86			1	28	<1	63						
	28				1	41			2	31			1	66								
	31				<1	100			1	44	1	59	4	13	4	13	1	39			1	39
	February 1										1	34										
	5										<1	69	<1	88	<1	79	<1	71				
	6[2]				1	52							2	39	2	38	1	56				
	11				<1	100	<1	79	<1	60	<1	50	1	48	<1	51	1	27	1	49	<1	76
	14												1	61	1	80	2	22			1	56
	15	16:00			3	25	1	46	2	32	6	26	1	66	1	67	1	65			1	100
		16:00			1	64	1	61	1	71	1	48	1	52	1	69	1	81			1	68
	16	10:00					1	35	<1	58	1	38	3524	4	3012	4	433	4	50	6	1	47
		10:00					<1	58	<1	67	1	74	3002	4	3251		398	5	61	4	1	29
		12:00											606	5	360	4	477	4	731	5	1207	5
		12:00													362	5	455	4	748	5		
		14:00[2]					2	23					528	7	472	7	1194	8				
		16:00					2	15	<1	74	1	39	117	5	115	5	116	5	122	5	289	5
		20:00							<1	49	<1	51	998	4	1276	4	1994	5	1687	5	236	5
	17	00:00					1	90	1	80	1	77	41	6	48	5	43	5	45	6	59	5
		08:00					1	58	7	11	5	34	24	7	18	7	21	6	16	8	11	10
		12:00					1	37	3	16	3	15	23	6	25	6	29	6	29	5	41	5
		16:00					<1	100	<1	76	<1	68	207	4	506	5	1406	4	1905	4	198	6
		20:00					2	84	1	71	1	55	15	19	13	9	7	12	12	8	9	9
	18	00:00					<1	73	3	19	1	44	11	11	10	7	11	7	11	7	8	8
		08:00					1	56	3	25	1	25	4	14	5	10	6	9	7	8	5	10
		16:00					<1	68	1	45	<1	64	3	25	11	7	4	12	4	12	3	14
	19	00:00					<1	83	<1	94	<1	83	6	16	7	10	4	12	5	12	3	15
		08:00					<1	72	<1	62	1	35	4	13	4	10	5	8	5	11	4	12
		16:00[2]					1	28					3	24	5	20	6	17				

Table 3 Continued.

Date		Time	Analysis - Total Suspended Solids ($mg.L^{-1}$)/Percent Organic[1]																	
			Station																	
			U5		S2		U2		U1		3		D1		D2		D3		D4		D5	
			$mg.L^{-1}$	%	$mg.L^{-1}$	%	$mg.L^{-1}$	%	$mg.L^{-1}$	%	$mg.L^{-1}$	%	$mg.L^{-1}$	%	$mg.L^{-1}$	%	$mg.L^{-1}$	%	$mg.L^{-1}$	%	$mg.L^{-1}$	%
	20	00:00					1	76	1	79	1	92	3	36	3	24	4	20	5	21	4	23
	20	08:00					<1	79	<1	67	<1	62	2	19	2	25	3	21	4	13	3	15
		16:00					<1	51	<1	86	1	46	3	14	4	11	5	11	6	10	4	11
	21	00:00					<1	77	<1	82	2	16	3	14	4	12	4	10	6	10	5	15
		08:00					1	49	1	57	1	47	1	21	2	17	2	17	3	16	2	19
		16:00			<1	100	<1	100	2	39	<1	100	1	54	2	28	2	25	2	35	2	32
	March 20						<1	56	<1	65			1	31			1	20				
	20[2]						1	59					1	54	1	45	<1	20				
	25						1	80	<1	100	<1	49	<1	100	<1	94	1	68	1	76	1	100
	June 1[2]						369	7					307	7	276	7	218	8				
	6								110	6							110	7			102	7
	7[2]						<1	95														
	14[2]		275	6																		
	19[2]						42	9					38	9	43	9	44	8				
	20[2]				2	21																
	27[2]						28	10	23	9			22	11	28	10	31	10				
	July 8[2]								6	12			6	12	6	12	7	12				
	16[2]						3	19	3	19			3	20	2	21	2	18				
	23								2	19	2	21			2	19	2	21	2	19		
	October 23		2	53	1	100			1	69			1	67	2	53	2	32			2	45
1986	January 31				1	56			3	27	1	37	2	21	2	20	4	12				
					<1	100			1	27	3	20	3	17	4	18	6	14				

[1]Percent organic - loss on ignition at 380°C for 16 hours.

[2]Analysis performed by R. Young, University of Guelph.

Table 4. Daily recorded water temperatures, Hodgson Creek 1983-1986.

Water Temperature 1983-1986

Date	Time	Stn.	Water °C	Air °C
1983 June 4		D1	7.0	
July 19	19:00	D1	15.5	
20	11:30	D1	13.0	
October 20	13:30	D1	1.5	
1984 January 29	17:00	S2	3.5	-21
30	17:00	U3	2.0	-24
31	16:00	S2	3.5	-20
		U3	2.0	-20
		U1	1.0	-20
		D1	0	-20
		D2	0	-20
		D5	0	-20
February 1	11:00	S2	4.0	
	11:00	U2	0.5	
	17:00	U1	0	-22
	17:00	D1	0	-22
2	10:00	S2	3.5	-27
		D8	0.5	-23
March 18	13:30	S2	5.0	-11
	13:00	U3	4.0	
	12:30	U1	3.0	-14
	16:00	D1	3.0	-10
	15:30	D2	3.0	-10
	15:30	D5	1.5	-10
19	10:00	D2	0.5	-20
	10:15	D5	0	-20
20	18:45	S2	5.0	-10
	18:45	U3	4.0	-10
	18:45	D1	2.0	-10
	18:45	D5	2.0	-10
21	10:00	S2	5.0	-10
	10:00	U3	4.5	-10
	10:00	U1	3.0	-10
	10:00	D1	2.0	-10
	10:00	D2	2.0	-10
	10:00	D5	2.0	-10
		D8	2.5	
June 30	17:00	S2	6.0	
	17:00	U4	11.0	
July 1	18:00	U5	5.5	
2	18:00	U5	5.5	
5	11:00	U5	8.5	
	22:00	U5	13.5	
6	11:00	S2	6.5	
	11:00	U5	10.0	
	13:30	U5	11.5	
	19:00	U5	14.0	
	19:00	U4	13.5	
August 24		S2	6.0	
		U4	10.5	
		D1	9.0	
25		U5	9.0	
		S2	6.0	
October 23	10:15	S2	4.5	-7
	10:45	U4	1.0	-7
	11:00	U5	0	-7
	12:00	U1	1.0	
	13:00	D1	0	

Date	Time	Stn.	Water °C	Air °C
1985 February 7	14:45	S1	5.0	-27
		S2	4.5	-27
		U3	3.0	-27
		U2	1.0	-27
		U1	1.0	-27
		B	0.5	-27
		D1	0	-27
		D3	0	-27
	16:00	D5	0	-27
11	14:00	S1	5.5	
		S2	5.0	
		U3	3.5	
		U2	0.5	
		U1	0	
		B	0	
		D1	0	
		D2	0	
		D3	0	
		D4	0	
	15:00	D5	0	
14	11:00	D1	0	-33
		D2	0	-33
	11:30	D3	0	-33
16	10:00	D1	0	
	10:30	D2	0	
	10:45	D3	0	
	11:15	D4	0	
	11:00	D5	0	
	17:05	U2	0.5	
	16:55	U1	0	
	16:50	B	0	
	16:45	D1	0	
	16:40	D2	0	
	16:35	D3	0	
	16:30	D4	0	
	16:15	D5	0	
17	14:30	U2	1.0	
	16:40	U1	1.0	
	16:45	B	0.5	
	14:15	D1	0	
	14:15	D2	0	
	14:15	D3	0	
	14:00	D4	0	
	14:00	D5	0	
	20:30	U2	1.0	
		U1	1.0	
		B	0.5	
		D1	0	
		D2	0	
		D3	0	
		D4	0	
	21:30	D5	0	
19	21:00	U2	0	
		U1	0	
		B	0	
		D1	0	
		D2	0	
		D3	0	
		D4	0	
	20:00	D5	0	

Table 4 Continued.

Water Temperature 1983-1996

Date	Time	Stn.	Water °C	Air °C
December 6	10:30	U2	1.5	
	10:15	U1	1.5	
	9:30	D1	1.0	
	10:00	D3	1.0	
7	12:00	U1	1.5	
8	11:00	U2	1.5	
	12:00	U3	2.5	
	12:15	U4	3.0	
	12:30	S2	5.0	
1985 January 31	14:00	D3	0	
February 2	14:00	U1	1.5	-23
	14:00	D3	0	-23
4	14:00	S1	5.0	-15
		S2	4.5	
		U3	3.0	
		U2	1.0	
		U1	0.5	
		B	0.5	
		D1	0	
		D2	0	
		D3	0	
	14:30	D5	0	
October 20	12:00	U5	0	
		S2	4.5	
		U1	1.5	
		D1	1.5	
		D2	1.0	
	12:30	D3	1.0	
1986 January 30	10:00	S2	4.5	
		U1	1.5	
		B	1.0	
		D1	0.5	
		D2	0	
		D3	0	

Table 5. Dissolved oxygen data for Hodgson Creek 1983-1986.

Analysis - Dissolved Oxygen/Temperature

Date		Station																	
		S2		U3		U2		U1		B		D1		D2		D3		D4		D5	
		$mg.L^{-1}$	°C	$mg.L^{-1}$	°C	$mg.L^{-1}$	°C	$mg.L^{-1}$	°C	$mg.L^{-1}$	°C	$mg.L^{-1}$	°C	$mg.L^{-1}$	°C	$mg.L^{-1}$	°C	$mg.L^{-1}$	°C	$mg.L^{-1}$	°C
1984	January 31	9.9	3.5			12.1	2.0	13.6	1.0			14.2	0	13.5	0			13.7	0		
	February 2	9.9	3.5																		
	5																				
	March 18	9.4	5.0	12.0	4.0	13.0	3.0														
	March 20			9.4	5.0	11.3	4.0					12.4	2.5					12.6	2.0		
1985	January 31	9.3	-			12.7	-	11.7	-	12.4	-	11.9	-	12.1	0	12.1	0			13.4	0
	February 4	9.2	4.5	10.9	3.0	13.0	1.0	13.0	0.5	13.4	0.5	13.3	0								
	7	9.1	4.5	10.5	3.0	12.2	1.0	12.5	0.5	13.2	0.5	13.3	0	13.5	0	13.6	0			13.3	0
	11	9.5	5.0	11.1	3.5	13.5	0.5	13.7	0	13.9	0	14.1	0	13.9	0	14.0	0	13.9	0	13.9	0
	17					13.1	1.0	13.4	1.0	13.8	0.5	13.5	0	13.5	0	13.6	0	13.7	0	13.6	0
	18					13.6	-	13.4	-	13.5	0	13.3	0	13.6	0	13.5	0	13.5	0	13.4	0
	19					13.1	0	13.0	0	13.0	0	13.7	0	13.7	0	13.7	0	13.6	0	13.1	0
Range		9.1	3.5	9.4	3.0	11.3	0	11.7	0	12.4	0	11.9	0	12.1	0	12.1	0	12.6	0	13.1	0
		9.9	5.0	12.0	5.0	13.6	4.0	13.7	1.0	13.9	0.5	14.2	2.5	13.9	0	14.0	0	13.9	2.0	13.9	0

Table 6. Water chemistry analysis for Hodgson Creek 1983-1986.

Analysis - Suspended Carbon $\mu g \cdot L^{-1}$

Date		Station										
		U5	S2	U2	U1	R	D1	D2	D3	D4	D5	Blank
1984	February 2		80	90	95		65	70		75		
	March 20			120	300		110	280		410		
	July 6	450	190	460	340		520	560	470			
	August 28		190	315	230		300	255	325			
	October 25	145	45	95	115		90	120	110			
	December 8		68		84	76	76	68				
1985	January 31		60		230		40					
	February 14-15		125	65	125	555	130	50	15		75	
	18				20		200		195			
	21-22		80	130	170	40	125	110	65	100	140	
	March 25			70	95	60	65	75	70	60	80	
	June 6				5250				5150		5010	6
	July 23				130	110		150	110	130		5
	October 23	170	110		170		110	260	200		170	<10
1986	January 30		390		390	150	510	130	380			<10
	Range	145	45	65	20	40	40	50	15	60	75	5
		450	390	460	5250	555	520	560	5150	410	5010	<10

Analysis - Dissolved Inorganic Carbon $\mu mole \cdot L^{-1}$

Date		Station										
		U5	S2	U2	U1	R	D1	D2	D3	D4	D5	Blank
1984	February 2		4050	4250	4250		4150	4250	4150			
	March 20			4200	4200		4200	4200	4200			
	July 6	2500	5000	2600	2800		2800	2900	2700			
	August 28		4400	3100	3400		3100	3200	3100			
	October 25	3250	4000	3500	3750		3550	3350	3250			
	December 8		4300		4500	4200	4300	4200				
1985	January 31		4500		4550		4550					
	February 14-15		4000	4150	3950	3900	4050	4100	4100		3950	
	18				4050		4100		4050			
	21-22		4000	4000	3900	4050	4050	3850	3850	3900	3950	
	March 25			4500	4500	4300	4300	4400	4300	4300	4300	
	June 6				1260				1360		1340	
	July 23				3200	3200		3200	3200	3200		20
	October 23	3700	4400		4000		4100	4050	4050		4000	
1986	January 30		3780		3760	3800	3750	3860	3720			10
	Range	2500	3780	2600	1260	3200	2800	2900	1360	3200	1340	10
		3700	5000	4500	4550	4300	4550	4400	4300	4300	4300	20

Analysis - Dissolved Organic Carbon $\mu mole \cdot L^{-1}$

Date		Station										
		U5	S2	U2	U1	R	D1	D2	D3	D4	D5	Blank
1984	February 2		110	90	90		90	90		90		
	March 20			50	80		50	90		90		
	July 6	690	150	600	620		640	600	600			
	August 28		40	330	350		340	330	370			
	October 25	330	30	250	260		260	270	260			
	December 8		490		640	530	610	540				
1985	January 31		110		180		150					
	February 14-15		170	120	150	120	120	160	200		170	
	18				130		130		120			
	21-22		110	90	80	110	130	150	100	150	120	
	March 25			120	160	80	120	110	120	110	100	
	June 6				390				380		400	
	July 23				340	340		440	310	390		10
	October 23	290	40		170		170	170	170		200	
1986	January 30		50		90	70	30	40	70			<10
	Range	290	30	50	80	70	30	40	70	90	100	<10
		690	490	600	640	530	640	600	600	390	400	10

Table 6 Continued.

Analysis - Suspended Nitrogen $\mu g \cdot L^{-1}$

Date		Station										
		U5	S2	U2	U1	R	D1	D2	D3	D4	D5	Blank
1984	February 2		<1	<1	<1		<1	<1		<1		
	March 20			<1	<1		<1	<1		<1		
	July 6	19	9	19	15		26	22	32			
	August 28			14	12		11	10	15			
	October 25	3	<1	<1	<1		<1	<1	<1			
	December 8		<1		2	<1	<1	<1				
1985	January 31		<1		5		<1					
	February 14-15		<1	<1	<1	<1	<1	<1	<1		<1	
	18				<1		<1		<1			
	21-22		<1	<1	2	<1	6	<1	<1	<1	2	
	March 25			2	<1	<1	1	<1	<1	<1	<1	
	June 6				175				175		181	<1
	July 23				3	1		3	2	2		1
	October 23	22	17		24		20	35	25		23	5
1986	January 30		4		6	6	10	4	11			1
	Range	3	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
		22	17	19	175	6	26	35	175	2	181	5

Analysis - Total Dissolved Nitrogen $\mu g \cdot L^{-1}$

Date		Station										
		U5	S2	U2	U1	R	D1	D2	D3	D4	D5	Blank
1984	February 2		190	170	180		200	180		190		
	March 20			250	270		250	320		250		
	July 6	350	270	310	300		320	340	310			
	August 28		210	230	240		210	240	230			
	October 25	280	180	230	240		250	230	230			
	December 8		210		280	230	240	240				
1985	January 31		210		210		210					
	February 14-15		200	210	210	210	200	210	210		200	
	18				260		260		260			
	21-22		220	200	210	210	290	280	210	200	230	
	March 25			230	220	230	220	220	240	180	210	
	June 6				240				230		230	
	July 23				190	210		190	190	190		40
	October 23	270	210		260		250	270	270		230	
1986	January 30		200		200	210	210	210	220			40
	Range	270	180	170	180	210	200	180	190	180	200	40
		350	270	310	300	230	320	340	310	250	230	

Analysis - Suspended Phosphorus $\mu g \cdot L^{-1}$

Date		Station										
		U5	S2	U2	U1	R	D1	D2	D3	D4	D5	Blank
1984	February 2		<1	<1	<1		<1	<1		<1		
	March 20			<1	<1		<1	<1		2		
	July 6	6	<1	6	5		7	9	7			
	August 28		<1	6	2		6	2	4			
	October 25	3	<1	2	2		3	2	<1			
	December 8		<1		<1	<1	1	<1				
1985	January 31		2		2		2					
	February 14-15				2	<1	<1	<1	<1		<1	
	18				<1		2		2			
	21-22		<1	<1	<1	<1	2	<1	2	2	3	
	March 25			2	2	<1	<1	<1	<1	<1	<1	
	June 6				63				65		62	<1
	July 23				3	2		3	2	2		<1
	October 23	2	7		10		2	9	2		1	<1
1986	January 30		8		7	7	6	5	8			<1
	Range	2	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
		6	7	6	63	7	7	9	65	2	62	

Table 6 Continued.

Analysis - Total Dissolved Phosphorus $\mu g \cdot L^{-1}$

Date		Station U5	S2	U2	U1	R	D1	D2	D3	D4	D5	Blank
1984	February 2		2	2	2		3	1		2		
	March 20			4	3		2	3		4		
	July 6	8	6	8	8		9	9	8			
	August 28		7	8	8		7	8	8			
	October 25	7	6	6	5		6	5	6			
	December 8		7		7	6	6	8				
1985	January 31		8		8		8					
	February 14-15		7	7	7	7	7	7	12		8	
	18				7		7		7			
	21-22		8	8	7	7	8	8	7	7	13	
	March 25			6	5	5	5	6	5	4	5	
	June 6				16				16		16	
	July 23				7	7		7	7	7		6
	October 23	7	24		40		10	35	10		8	
1986	January 30		3		4	3	3	3	2			5
	Range	7	2	2	2	3	2	1	2	2	5	5
		8	24	8	40	7	10	35	16	7	16	6

Analysis - Soluble Reactive Phosphorus $\mu g \cdot L^{-1}$

Date		Station U5	S2	U2	U1	R	D1	D2	D3	D4	D5
1984	February 2		<1	1	1		<1	<1		1	
	March 20			<1	1		<1	<1		<1	
	July 6	1	<1	1	1		1	<1	1		
	August 28		1	1	1		2	1	1		
	October 25	<1	<1	<1	<1		<1	2	<1		
	December 8		<1		1	<1	<1	<1			
1985	January 31		<1		<1		<1				
	February 14-15		<1	<1	<1	<1	<1	2	<1		<1
	18				1		<1		1		
	21-22		<1	<1	<1	<1	<1	<1	<1	1	6
	March 25			<1	<1	<1	<1	1	<1	<1	<1
	June 6				9				12		10
	July 23				<1	<1		<1	<1	<1	
	October 23	1	17		34		6	31	6		3
1986	January 30		<1		<1	<1	<1	<1	<1		
	Range	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
		1	17	1	34		6	31	12	1	10

Analysis - Soluble Reactive Silicon $mg \cdot L^{-1}$

Date		Station U5	S2	U2	U1	R	D1	D2	D3	D4	D5	Blank
1983	October 20						2.20					
1984	February 2		2.79	2.78	2.78		2.77	2.77		2.77		
	March 20		2.77	2.76	2.76		2.71	2.70		2.69		
	July 6	1.59	2.73	1.69	1.71		1.69	1.71	1.69			
	August 28		2.70	1.73	1.72		1.73	1.73	1.73			
	October 25	1.86	2.75	2.05	2.04		2.05	2.07	2.05			
	December 8		2.80		2.63	2.62	2.60	2.59				
1985	January 31		2.71		2.69		2.65					
	February 14-15		2.79	2.75	2.75	2.74	2.73	2.73	2.71		2.69	
	18			2.79		2.77		2.76				
	21-22		2.79	2.76	2.74	2.76	2.75	2.75	2.75	2.75	2.74	
	March 25			2.71	2.68	2.69	2.66	2.65	2.65	2.65	2.63	
	June 6				8.40				8.39		8.43	
	July 23				1.83	1.84		1.84	1.84	1.84		
	October 23	1.84	2.75		2.35		2.33	2.33	2.31		2.31	
1986	January 30		2.82		2.72	2.76	2.73	2.73	2.73			<0.01
	Range	1.59	2.70	1.69	1.71	1.84	1.69	1.71	1.69	1.84	2.31	<0.01
		1.86	2.82	2.78	8.40	2.76	2.77	2.77	8.39	2.77	8.43	

Table 6 Continued.

Analysis - Total Suspended Iron $\mu g.L^{-1}$

Date	Station U5	S2	U2	U1	R	D1	D2	D3	D4	D5	Blank
1984 February 2		2	21	17		4	4		9		
March 20		9	<1	9		5	5		91		
July 6	303	24	288	204		305	383	351			
August 28		6	130	126		138	116	155			
October 25	72	3	38	38		38	51	43			
December 8		5		5	8	11	9				
1985 January 31		21		16		8					
February 14-15				<1	10	3	<1	<1		<1	
18				3		36		36			
21-22		1	<1	24	<1	19	25	22	26	34	
March 25			6	6	4	8	5	4	7	5	
June 6				2620				2626		2596	
July 23				68	57		68	60	69		1
October 23	28	7		18		18	28	45		18	2
Range	28	1	<1	<1	<1	3	<1	<1	7	<1	1
	303	24	288	2620	57	305	383	2626	91	2596	2

Analysis - Iron $\mu g \cdot L^{-1}$

Date	Station U5	S2	U2	U1	R	D1	D2	D3	D4	D5	Blank
1983 October 20						<0.04					
1984 February 2		<0.04*	<0.04*	<0.04*		<0.04*	0.05		<0.04*		
March 20			0.05	0.05		0.05	0.05		<0.05		
July 6	<0.04	<0.04	0.04	0.04		0.04	<0.04	0.04			
August 28		<0.04	<0.04	<0.04		<0.04	<0.04	<0.04			
October 25	0.07	<0.04*	<0.04*	<0.04*		<0.04*	<0.04*	<0.04*			
December 8		0.08		0.08	0.08	0.04	0.08				
1985 January 31		<0.04		<0.04		<0.04					
February 14-15		<0.04	<0.04	<0.04	<0.04	<0.04	<0.04		<0.04		
18				<0.04		<0.04		<0.04			
21-22		<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	
March 25			<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	
June 6				0.12				0.28		0.24	
July 23				0.04	0.04		<0.04	<0.04	<0.04		<0.04
October 23	<0.04	<0.04		<0.04		<0.04	<0.04	<0.04		<0.04	
Range	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
	0.07	0.08	0.05	0.12	0.08	0.05	0.08	0.28	<0.05	0.24	

*Note - values originally given as 0.03.

Analysis - Magnesium $mg \cdot L^{-1}$

Date	Station U5	S2	U2	U1	R	D1	D2	D3	D4	D5	Blank
1983 October 20						24.4					
1984 February 2		26.7	27.2	26.7		26.4	26.4		27.4		
March 20			28.3	28.3		28.7	27.8		28.5		
July 6	7.03	13.9	7.8	7.8		7.7	7.7	7.7			
August 28	18.5	29.7	14.8	16.5		16.7	16.7	16.5			
October 25		28.6	20.4	20.2		20.6	20.2	20.6			
December 8		29.6		27.4	27.6	27.2	27.2				
1985 January 31		28.2		28.9		28.5					
February 14-15		28.2	27.9	27.9	27.6	27.8	28.1	27.6		28.1	
18				28.1		28.4					
21-22		28.2	28.2	27.8	28.2	27.9	27.9	28.1	28.1	27.6	
March 25			27.8	28.2	27.8	28.2	28.2	28.2	28.0	27.7	
June 6				6.3				6.3		6.4	
July 23				17.1	17.2		17.2	17.3	17.2		0.13
October 23	19.2	28.0		24.7		24.1	24.0	23.8		24.0	
1986 January 30		29.9		29.5	29.0	29.2	29.2	29.6			0.17
Range	7.03	13.9	7.67	6.28	17.2	7.67	7.67	6.28	17.2	6.4	0.13
	19.2	29.9	28.3	29.5	29.0	29.2	29.2	29.6	28.5	28.1	0.17

Table 6 Continued.

Analysis - Organic Acids $\mu eq \cdot L^{-1}$

Date		Station										
		U5	S2	U2	U1	B	D1	D2	D3	D4	D5	Blank
1984	February 2											
	March 20			<1	<1		<1	<1		<1		
	July 6	104	<1	89	188		89	88	89			
	August 28		40	72	76		56	50	68			
	October 25											
	December 8											
1985	January 31		105		124		86					
	February 14-15		166	122	114	85	106	84	64		84	
	18				84		36		35			
	21-22		131	61	82	61	73	55	60	82	79	
	June 6				18				20		26	
	July 23				5	11		13	22	27		1.0
	October 23	<1	<1		<1		<1	<1	<1		6	
1986	January 30		<1		<1	<1	<1	<1	<1			
	Range	<1	<1	<1	<1	<1	<1	<1	<1	<1	6	1.0
		104	166	122	188	85	106	88	89	82	84	

Analysis - Potassium $mg \cdot L^{-1}$

Date		Station										
		U5	S2	U2	U1	B	D1	D2	D3	D4	D5	Blank
1983	October 20						0.91					
1984	February 2		1.21	1.21	1.21		1.16	1.14		1.16		
	March 20			1.19	1.19		1.15	1.23		1.25		
	July 6	0.59	1.26	0.65	0.63		0.69	0.65	0.63			
	August 28		1.22	0.62	0.62		0.62	0.62	0.62			
	October 25	0.71	1.51	0.85	0.85		0.85	0.85	0.85			
	December 8		1.26		1.20	1.20	1.16	1.16				
1985	January 31		1.22		1.28		1.24					
	February 14-15		1.24	1.20	1.22	1.18	1.22	1.16	1.20		1.16	
	18				1.26		1.20		1.49			
	21-22		1.20	1.26	1.22	1.29	1.24	1.26	1.24	1.22	1.24	
	March 25			1.16	1.16	1.16	1.16	1.18	1.16	1.12	1.14	
	June 6				0.53				0.59		0.61	
	July 23				0.74	0.74		0.74	0.72	0.74		0.02
	October 23	0.65	1.23		1.02		0.98	1.02	0.98		1.00	
1986	January 30		1.18		1.16	1.16	1.12	1.14	1.14			0.19
	Range	0.59	1.18	0.62	0.53	0.74	0.62	0.62	0.59	0.74	0.61	0.02
		0.71	1.51	1.26	1.28	1.29	1.24	1.26	1.49	1.25	1.24	0.19

Analysis - Sodium $mg \cdot L^{-1}$

Date		Station										
		U5	S2	U2	U1	B	D1	D2	D3	D4	D5	Blank
1983	October 20						6.2					
1984	February 2		10.7	10.7	11.3		11.5	10.7		10.9		
	March 20			10.4	10.8		10.6	10.6		10.5		
	July 6	1.2	10.5	1.9	2.0		1.9	1.9	2.0			
	August 28		10.4	2.2	2.2		2.2	2.2	2.1			
	October 25	1.4	10.0	3.5	3.5		3.5	3.4	3.5			
	December 8		10.0		8.6	8.75	8.4	8.4				
1985	January 31		10.7		11.2		10.7					
	February 14-15		10.5	10.3	10.8	10.6	10.6	10.8	10.3		10.8	
	18				10.8		10.7		10.9			
	21-22		10.5	11.0	10.3	10.8	10.8	11.2	10.8	10.3	10.6	
	March 25			11.5	12.5	12.0	11.8	11.7	11.8	11.7	11.5	
	June 6				1.0				1.0		1.0	
	July 23				3.0	3.03		3.1	3.0	3.0		0.15
	October 23	2.0	10.8		7.0		7.1	7.0	6.9		6.8	
1986	January 30		11.9		12.0	12.6	11.3	11.6	11.7			
	Range	1.2	10.0	1.9	1.0	3.03	1.9	1.9	1.0	3.0	1.0	0.15
		2.0	11.9	11.5	12.5	12.6	11.8	11.7	11.8	11.7	11.5	

Table 6 Continued.

Analysis - Chloride $mg \cdot L^{-1}$

Date		Station U5	S2	U2	U1	B	D1	D2	D3	D4	D5	Blank
1984	February 2		5.0	5.2	5.2		5.7	5.8	5.8			
	March 20			4.9	5.5		5.1	5.1	5.1			
	July 6	0.1	4.6	0.5	1.1		0.5	0.7	0.5			
	August 28		5.4	1.0	1.2		1.0	1.0	1.0			
	October 25	0.5	4.5	1.4	1.4		1.5	1.4	1.4			
	December 8		4.5		5.0	4.0	4.5	4.0				
1985	January 31		5.7		4.9		5.6					
	February 14-15		4.6	4.7	4.6	4.8	4.9	4.8	4.8			
	18				5.3		5.3		5.3			
	21-22		4.9	4.9	4.8	4.9	5.1	5.1	4.9	4.9	5.1	
	March 25			5.0	5.0	5.6	5.6	5.6	5.6	5.6	5.6	
	June 6				0.4				0.6		0.6	
	July 23				1.5	1.0		1.0	1.0	1.5		0.1
	October 23	<1.0	4.0		3.0		2.0	3.0	2.0		2.0	
1986	January 30		5.0		5.0	5.0	5.0	5.0	5.0			<0.1
	Range	0.1	4.0	0.5	0.4	1.0	0.5	0.7	0.5	1.5	0.6	<0.1
		<1.0	5.7	5.2	5.5	5.6	5.7	5.8	5.8	5.6	5.6	0.1

Analysis - Sulphate $mg \cdot L^{-1}$

Date		Station U5	S2	U2	U1	B	D1	D2	D3	D4	D5	Blank
1984	February 2		89.6	84.0	86.4		88.8	85.6		84.0		
	March 20			95.8	106.0		96.6	97.4		97.4		
	July 6	27.5	87.5	33.3	33.3		33.3	33.8	33.3			
	August 28		83.5	34.4	35.2		35.2	34.4	34.4			
	October 25	38.8	82.1	49.5	49.8		49.8	48.5	49.5			
	December 8		80.0		77.5	76.5	75.5	76.0				
1985	January 31		75.7		73.5		75.7					
	February 14-15		74.7	76.6	73.8	73.8	73.8	73.8	74.7		73.8	
	18				77.3		77.3		77.3			
	21-22		75.6	75.6	74.7	75.6	74.7	75.6	75.6	75.6	75.6	
	March 25			83.0	82.0	84.8	84.0	84.0	84.0	83.2	84.0	
	June 6				17.0				17.2		17.2	
	July 23				39.0	39.5		39.0	39.0	39.0		<0.1
	October 23	44.0	82.0		66.0		65.0	65.0	64.0		64.0	
1986	January 30		95.0		95.0	95.0	92.0	92.0	91.0			<0.1
	Range	27.5	74.7	33.3	17.0	39.5	33.3	33.8	17.2	39.0	17.2	<0.1
		44.0	95.0	95.8	106.0	95.0	96.6	97.4	91.0	97.4	84.0	

Analysis - Calcium $mg \cdot L^{-1}$

Date		Station U5	S2	U2	U1	B	D1	D2	D3	D4	D5	Blank
1983	October 20						63.9					
1984	February 2		65.5	65.5	64.4		70.9	69.3		73.1		
	March 20			69.1	68.6		69.1	69.1		69.1		
	July 6	43.9	59.1	45.6	46.6		45.7	45.4	45.2			
	August 28		68.6	54.3	56.1		53.9	53.9	53.0			
	October 25	59.4	62.3	57.4	58.1		57.6	57.2	58.9			
	December 8		62.1		67.9	66.8	67.9	65.8				
1985	January 31		65.3		67.2		66.3					
	February 14-15		65.3	64.4	64.4	59.6	64.4	65.3	64.4		65.3	
	18				63.4		64.4		61.5			
	21-22		66.3	64.4	63.4	64.4	64.4	63.4	64.4	63.4	63.4	
	March 25			64.2	63.7	64.2	64.2	64.2	64.2	64.2	64.2	
	June 6				21.1				21.1		21.1	
	July 23				45.7	45.3		45.7	45.4	45.4		0.3
	October 23	61.3	63.0		63.0		62.2	61.3	61.3		61.3	
1986	January 30		68.9		69.7	71.5	68.9	67.2	67.2			
	Range	43.9	59.1	45.6	21.1	45.3	45.7	45.4	21.1	45.4	21.1	0.3
		61.3	68.9	69.1	69.7	71.5	70.9	69.8	67.2	73.1	65.3	

Table 6 Continued.

Analysis - Conductivity @ 25°C $\mu S \cdot cm^{-1}$

Date		Station U5	S2	U2	U1	R	D1	D2	D3	D4	D5
1983	October 20						480				
1984	February 2		550	540	540		540	540		540	
	March 20			550	550		550	550		540	
	July 6	300	530	330	330		320	330	330		
	August 28		550	360	350		360	360	360		
	October 25	394	546	434	427		434	433	435		
	December 8		543		533	538	533	533			
1985	January 31		552		547		547				
	February 14-15		549	539	544	524	544	539	544		544
	18				544		549		549		
	21-22		549	549	539	549	549	549	544	544	544
	March 25			552	552	552	552	552	552	552	552
	June 6				162				163		164
	July 23				368			368	369	368	368
	October 23	433	551		504		500	501	499		497
1986	January 30		566		562	560	556	560	556		
	Range	300	530	330	162	524	320	330	163	368	164
		433	566	552	562	560	556	560	556	552	552

Analysis - pH

Date		Station U5	S2	U2	U1	R	D1	D2	D3	D4	D5
1984	February 2		8.14	8.36	8.32		8.36	8.38		8.38	
	March 20			8.40	8.42		8.48	8.52		8.50	
	July 6	8.51	8.34	8.47	8.46		8.48	8.52	8.48		
	August 28		8.28	8.33	8.29		8.35	8.37	9.40		
	October 25	8.28	8.18	8.28	8.26		8.33	8.32	8.33		
	December 8		8.46		8.40	8.45	8.39	8.50			
1985	January 31		8.20		8.19		8.20				
	February 14-15		8.21	8.46	8.40	8.35	8.39	8.45	8.42		8.41
	18				8.45		8.47		8.49		
	21-22		8.31	8.44	8.47	8.47	8.42	8.38	8.47	8.54	8.46
	March 25			8.24	8.26	8.36	8.26	8.34	8.34	8.34	8.36
	June 6				8.10				8.14		8.17
	July 23				8.31	8.40		8.39	8.40	8.42	
	October 23	8.27	7.92		8.33		8.35	8.36	8.35		8.37
1986	January 30		8.34		8.41	8.41	8.41	8.40	8.44		
	Range	8.27	7.92	8.24	8.10	8.35	8.20	8.32	8.14	8.34	8.17
		8.51	8.46	8.47	8.47	8.47	8.48	8.52	8.49	8.54	8.46

Analysis - Alkalinity $\mu eq \cdot L^{-1}$

Date		Station U5	S2	U2	U1	R	D1	D2	D3	D4	D5
1983	October 20						4240				
1984	February 2										
	March 20										
	July 6										
	August 28										
	October 25	3610	4360	3770	3770		3780	3770	3820		
	December 8		4360		4380	4400	4380	4390			
1985	January 31										
	February 14-15		4340	3170	3280	3310	3280	3310	3480		3460
	18				3810		3730		3810		
	21-22		3680	3560	3480	4430	4490	3470	3780	3510	4450
	March 25			4380	4390	4400	4370	4360	4370	4360	4400
	June 6				1410				1420		1450
	July 23				3240	3280		3240	3180	3240	
	October 23	3940	4440		4200		4160	4220	4150		4180
1986	January 30		4340		4320	4320	4320	4320	4300		
	Range	3610	3680	3170	1410	3280	3280	3240	1420	3240	1450
		3940	4440	4380	4390	4430	4490	4390	4370	4360	4450

Table 7. Station catch frequency data, Hodgson Creek, 1983-1986.

	U5	U4	U3	U2	U1	D1	D2	D3	D4	D5	Total
Arctic grayling	3	28	138	28	6	26	40	14	4	13	299
Slimy sculpin	1	1	26	2	5	4	14	4	0	2	59
Lake chub	0	7	2	0	4	5	4	1	0	2	25
Longnose sucker	0	0	1	0	2	1	1	0	0	1	6
Burbot	0	0	0	0	0	0	1	0	0	1	2
Northern pike	0	0	0	2	0	0	0	0	0	0	2

Table 8. Seasonal age frequency distribution and growth in length data for Arctic grayling from Hodgson Creek, 1983-1986.

Summer					
Age Class	N	Mean L.	S.D.	Min.	Max.
0	15	39.3	16.9	25	81
1	21	99.9	13.9	74	129
3	7	187.9	21.0	159	217
4	13	240.9	29.6	165	275
5	10	242.9	22.9	202	290
6	5	280.2	43.1	247	338
7	7	296.7	24.1	266	334
9	1	333.0	-	333	333
10	1	369.0	-	369	369
Winter					
Age Class	N	Mean L.	S.D.	Min.	Max.
0	60	68.4	9.3	49	99
1	86	104.8	9.8	80	136
2	48	129.4	11.3	101	153
3	24	158.0	15.4	131	195
4	12	187	21.2	152	223
Total					
Age Class	N	Mean L.	S.D.	Min.	Max.
0	75	62.5	16.1	25	99
1	107	103.8	10.8	74	136
2	48	129.4	11.3	101	153
3	31	164.8	20.8	131	217
4	25	215.0	37.4	152	275
5	10	242.9	22.9	202	290
6	5	280.2	43.1	247	338
7	7	296.7	24.1	266	334
9	1	333.0	-	333	333
10	1	369	-	369	369

Table 9. Detailed stomach analysis for Arctic grayling from Hodgson Creek, 1983.

Fish Length Interval	≤100				101 - 200		201 - 300		>300	
Sampling Period	II		III		III		II		II	
Fork Length Range	25 - 34		55 - 71		115 - 142		201 - 299		333 - 369	
No. Stomachs Analyzed/ No. Empty	11/0		5/0		4/0		5/0		4/0	
No. Organisms/Stomach	25.8		83.4		4.5		312.2		260.0	
Food Item	**% by number**	**% by occurrence**								
Insecta										
Diptera										
adult	2.1	36.4					0.3	60.0	0.4	50.0
larvae										
Chironomidae	90.2	100.0	99.0	100.0			2.2	60.0	0.9	50.0
Simuliidae	3.9	54.5					1.1	20.0	1.1	75.0
Plecoptera							0.2	40.0		
Ephemeroptera	2.5	54.5					0.2	60.0	0.4	50.0
Trichoptera			1.0	40.0	100.0	100.0	1.6	100.0	2.1	100.0
Coleoptera										
adult							0.4	40.0	3.2	100.0
larvae	0.4	9.1					0.8	80.0		
Hymenoptera							92.4	100.0	89.9	100.0
Lepidoptera										
adult							0.1	20.0	0.8	50.0
Hemiptera							0.4	60.0	0.7	100.0
Homoptera			1.1	9.1						
Arachnida										
Hydracarina							0.1	20.0		
Araneida							0.3	40.0	0.7	75.0

Sampling Periods - II July
III October

Table 10. Detailed stomach analysis for Arctic grayling from Hodgson Creek, 1984.

Fish Length Interval			≤100			101 - 200				
Sampling Period			I	II	III	I	II	III		
Fork Length Range			58 - 99	52 - 99	66 - 94	103 - 173	103 - 159	105 - 155		
No. Stomachs Analyzed/ No. Empty			45/5	5/0	3/2	15/2	2/0	4/2		
No. Organisms/Stomach			28.2	13.6	17.3	28.5	28.5	0.3		
Food Item	% by number	% by occurrence								
Insecta										
Diptera										
adult			54.2	60.0			64.9	50.0		
larvae			11.1	60.0						
Chironomidae	89.8	62.2				89.9	66.7			
Simuliidae										
Plecoptera	1.3	20.0	11.1	80.0		2.7	20.0	5.3	50.0	100.0 50.0
Ephemeroptera	7.7	40.0	2.8	40.0		4.6	33.3	1.8	50.0	
Trichoptera	0.5	6.7	15.3	80.0	100.0 33.3	1.5	13.3	10.5	100.0	
Coleoptera										
adult	0.1	2.2	1.4	20.0			1.8	50.0		
larvae										
Hymenoptera			2.8	20.0			15.8	100.0		
Lepidoptera										
adult										
Hemiptera	0.2	6.7				0.6	13.3			
Homoptera										
Arachnida										
Hydracarina	0.4	11.1				0.6	13.3			
Araneida										
Crustacea			1.4	20.0						

Sampling Periods - I February/March
II August
III October

Table 11. Detailed stomach analysis for Arctic grayling from Hodgson Creek, 1985.

Fish Length Interval (mm)	≤100						101 - 200						201 - 300			>300	
Sampling Period	I		II		III		I		II		III		I	II	III	II	
Fork Length Range	49 - 100		74 - 100		59 - 100		101 - 164		101 - 181		101 - 180		205	214 - 292	216 - 223	308 - 315	
No. Stomachs Analyzed/																	
No. Empty	20/4		10/0		38/16		47/12		11/0		43/3		1/1	18/1	2/2	2/0	
No. Organisms/Stomach	63.9		35.3		4.7		27.9		39.4		10.3		0	47.4	0	61.0	
Food Item	% by number	% by occurrence															
Insecta																	
Diptera																	
adult			14.1	90.0	0.6	2.6	0.2	2.1	13.4	81.8	3.5	15.8		27.4	94.1	27.1	100.0
larvae																	
Chironomidae			0.3	10.0													
Simuliidae			5.1	50.0										2.6	58.8	0.8	50.0
Orthocladinae	32.9	35.0	51.3	90.0	12.2	39.5	83.0	68.1	3.0	36.4	15.4	58.1		1.2	35.3	0.8	50.0
Limnophora			0.3	10.0							0.5	2.6		0.1	5.9		
Pericoma																	
Tanypodinae			1.1	40.0	0.6	2.6	0.1	2.1			0.2	2.3		0.6	5.9		
Plecoptera																	
Alloperla			0.8	20.0	29.4	18.4	0.7	10.6	2.5	27.3	14.3	27.9		3.5	64.7	2.5	100.0
Capnia	49.3	50.0			24.4	18.4	0.2	4.3			17.9	9.3					
Malenka											0.2	2.3					
Isoperla	0.2	5.0			2.2	5.3	0.1	2.1	0.2	9.1	0.7	2.3		0.9	29.4		
Other and unident	17.1	15.0			9.4	13.2	14.7	12.8			11.1	23.3					
Ephemeroptera																	
Baetis			2.5	30.0	2.8	10.5	0.1	2.1	0.7	18.2	1.8	9.3		2.0	41.2	4.1	50.0
Cinygmula	0.2	10.0	0.8	20.0	4.4	7.9	0.4	6.4	0.5	9.1	0.7	2.3		0.7	23.5		
Ephemerella	0.1	5.0	0.3	10.0	1.1	2.6	0.2	6.4	0.2	9.1	0.9	9.3		0.5	17.6		
Other			2.0	30.0			0.2	4.3			1.4	9.3					
Trichoptera																	
Limnophilus			0.3	10.0	10.6	15.8	0.1	2.1			24.4	53.5					
Brachycentrus			0.3	10.0					3.2	54.5	2.0	18.6		1.5	29.4	1.6	50.0
Coleoptera																	
adult			1.1	30.0	0.6	2.6			6.9	90.1	2.0	18.6		17.2	94.1	15.6	100.0
larvae			0.3	10.0					0.5	18.2	0.2	2.3		1.1	29.4	0.8	50.0
Hymenoptera																	
Formicidae			9.1	100.0					21.9	90.1	0.9	7.0		36.1	100.0	41.0	100.0
Lenthredinidae			0.3	10.0							0.2	2.3					
Lepidoptera																	
adult			5.9	10.0										0.6	29.4		
Hemiptera			2.3	50.0					3.7	54.5	0.5	4.7		3.6	64.7	4.9	50.0
Arachnida																	
Hydracarina	0.3	10.0	0.3	10.0	1.7	7.9	0.2	2.1	0.2	9.1	0.9	4.7					
Araneida			1.4	20.0					0.7	27.3	0.2	2.3		0.2	11.8	0.8	50.0

Sampling Periods - I February/March
II June/July
III October

Table 12. Detailed stomach analysis for Arctic grayling from Hodgson Creek, 1986.

Fish Length Range	≤100		101 - 200	
Sampling Period	I		I	
Fork Length Range	80 - 98		101 - 195	
No. Stomachs Analyzed/ No. Empty	6/1		20/1	
No. Organisms/Stomach	9.5		28.7	
Food Item	% by number	% by occurrence	% by number	% by occurrence
Insecta				
Diptera				
adult				
larvae				
Chironomidae				
Simuliidae				
Orthocladinae	29.8	66.7	10.1	80.0
Limnophora				
Pericoma				
Tanypodinae			0.4	10.0
Plecoptera				
Alloperla	1.8	16.7	12.2	65.0
Capnia				
Malenka			0.2	5.0
Isoperla			0.7	10.0
Other and unident	66.7	83.3	72.7	85.0
Ephemeroptera				
Baetis	1.8	16.7	1.9	45.0
Cinygmula				
Ephemerella				
Other				
Trichoptera				
Limnophilus			1.6	30.0
Brachycentrus				
Coleoptera				
adult				
larvae				
Hymenoptera				
Formicidae				
Lenthredinidae				
Lepidoptera				
adult				
Hemiptera				
Arachnida				
Hydracarina			0.4	10.0
Araneida				